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An Illustrated Weekly Journal

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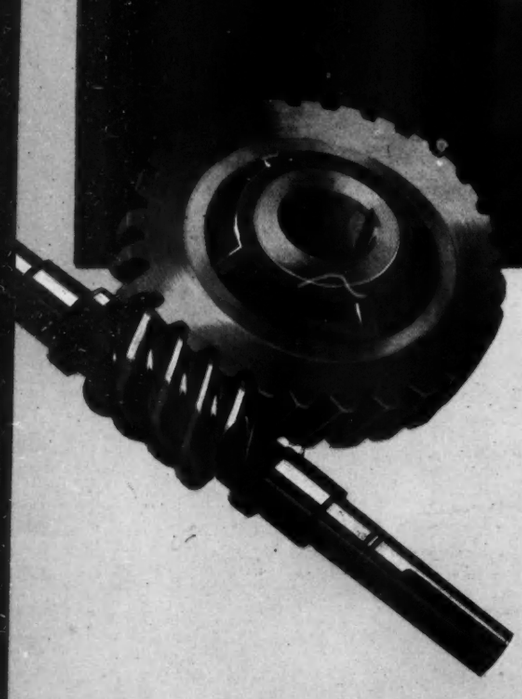

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An Illustrated Weekly Journal

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ACCORDING TO OUR CLOTH

A MAN finding himself marooned on a deserted island does not immediately set himself to build a steamship. He looks around, decides whether or not he has any hope of escape, and if not, counts his assets and makes himself as comfortable as possible. He may even be better off than he was at home: fruit in abundance, fish in plenty and an eternity of peace and quiet. But to presume on the benevolence of one's environment is to be eaten by a tiger, and to count on nuts and bolts where nuts and bolts are not available is no less hazardous. This lesson Britain seems slow to learn. Nevertheless, a change is taking place, and the power station at Calder Hall is a sign of the new wisdom.

The Calder Hall reactors, as most of us must know, are based on the gas-cooled graphite-moderated system and use natural uranium as fuel. Nuclear economists may assure us that this is by no means an ideal combination. Neutron efficiency might well be higher if the moderator were heavy water; the capital plant could be smaller and therefore cheaper if the fuel were enriched. However, the production of enriched uranium requires in the first place abundant sources of uranium ore; secondly, vast and expensive isotope separation plants; and lastly, plenty of time. Similar considerations apply to the manufacture of heavy water. However, Britain is short of all these, and is especially short of time.

In fact, the decision to go ahead with a full-scale nuclear power programme arose from a correct assessment of the immediacy of our needs. It may be many years before our coal supplies are finally exhausted, but already the difficulty of extracting coal from poor deposits, in barely accessible seams, is putting up the price. Four per cent. of our requirements are imported. The advent of nuclear power is a timely opportunity and we have been wise to take it. Those responsible have recognised both the extent of our need and the limitations of our resources and acted accordingly. The primary purpose of the Calder Hall reactors is to produce plutonium; but whether or not we consider its use for nuclear weapons justified by Britain's place in the world, plutonium is a valuable product. The reactors of the future may well depend upon it for fuel enrichment.

The preparations being made for these advanced reactors are another example of correct assessment and thoughtful planning. We cannot afford to build a wide range of small-scale prototype reactors based on different combinations of fuel, moderator and coolant, for such installations are extremely expensive and the fuel to run them is not available. Instead, we build materials testing reactors such as DIDO, in which the component parts of proposed prototype systems can be inserted, and so tested under operating conditions. By planning as far as possible on paper and using analogue computers, we may well reach the right answer before those who can afford to be prodigal with their resources.

The foresight and appraisal shown by the Atomic Energy Authority are unfortunately not always in evidence elsewhere in Britain. In some quarters the conditions of the last century are still assumed: we have only to build things and sell them overseas and all our needs will be satisfied. But circumstances have changed. Now it is dangerous to assume that a Brazilian cannot build a locomotive or that an Egyptian cannot steer a ship. If technical superiority were a cumulative or geometrical function we might hope to remain ahead automatically. True, a fact is a hook on which two facts will hang, but, to change the metaphor to biology, the rate of increase depends too on the interval between generations. Often a technical tradition can be a disadvantage, for once a nation becomes set in a mould, advance becomes difficult, as it is difficult to build modern roads in an ancient city.

Because of this inertia we have been slow to recognise the new world situation and the extent of the need for technolgists. We have said in effect: the Americans and Russians can expand their industries until they have refrigerators in every room and tractors in every acre, but why should we? We are comfortable as we are. Unfortunately, we shall not remain comfortable. If we have to share our present wealth with a few backward nations, as we surely must—for prosperity seems in the modern world to flow from points of high to points of low concentration—then soon our standard of living will be much deflated. Thus if we are to retain our comforts, we cannot adopt a cosy isolation, but must assist in satisfying the new world demand. Our part will be to supply the latest subtleties of technology, for the standard products the so-called backward countries can already make themselves. To succeed in this we must shorten the interval between generations in the accumulation of technical knowledge. That means more technologists.

This seems to be the reality of our situation, a reality we have yet to accept and act upon. The Atomic Energy Authority under the leadership of a scientist and an engineer have shown the way. If it falls to us to shorten our front and concentrate our forces, that we should do, not dissipate our strength in ineffective demonstrations. We have come a long way from the primitive conditions of

our deserted island but the law of the jungle still remains: " Adapt or perish." To adapt to a given situation it is necessary first to recognise what that situation is.

* * *

Plain Words

Whatever the psychologists may say, there are three types of men who inhabit the high places in industry: the profession-conscious (usually scientists), the publicity-conscious (usually successful chairmen or managing directors), and the community-conscious (usually competent engineers).

The profession-conscious come close to industrial heresy. They are like housewives who believe that dusting and polishing are ends in themselves. They are so wrapt up in their professions that they are blind to their true function in society. The community-conscious have more to commend them. Their function in society is their first thought, but professional decorum is a secondary consideration. What of the publicity-conscious ?

The old saying that good wine needs no bush dies hard in Britain. Certainly it sufficed throughout the whole of the Nineteenth Century, when we had everything, or nearly everything, our own way. But other countries now make good wine; and they tell the world. Propaganda, too, is a word that sticks in the gullet. It carries certain overtones from the second World War which militate against a rational acceptance of its significance. Put all these misconceptions aside, look at the flood of words and pictures from radio, television, newspapers and magazines that nearly drown the human senses, and it is clear that anyone who wants to communicate with his unseen customers, friends and competitors must plan his communication deliberately. He must use all the modern knowledge of man's reactions to his " publicity " environment, or at least employ someone to do it for him. A quick and persuasive appeal for more effective public relations work comes from Mr. " Mike " Williams-Thompson, a restless publicist, in his latest book *Tell the People* ! He gets off to a good start with a chapter on " The Decline of Socialism." Without decrying the doings of the post-war Labour Party, he blames their split into factions, their lack of a clear policy, on weak propaganda. They failed to explain their actions and even their true aspirations to their followers and the public in general.

He touches on some delicate questions in relation to the Royal Family, Britain in the cold war and the Middle East, and some of the amateur efforts in industrial affairs, especially by the trade unions. It is good that someone can write so outspokenly about the weak spot in our relations with each other and with other countries. His plain words will offend some who read them, but the majority of readers will accept the force of his argument. There is so much that the people must be told.

R. B. Williams-Thompson, *Tell the People* ! World's Press News Publishing Co. Ltd., London. (12*s*. 6*d*.)

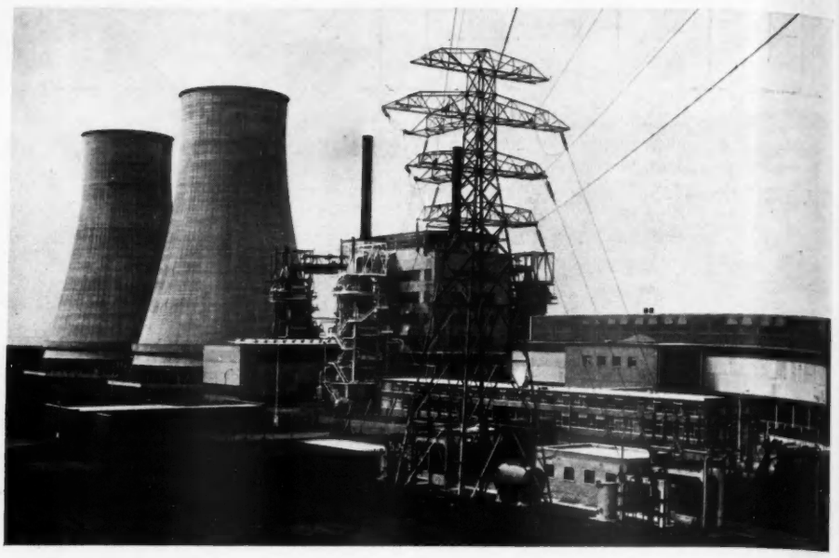


Fig. 1 General view of the Calder Hall nuclear power station, which on October 17 is to be opened by Her Majesty the Queen. The turbine house and one reactor building can be seen.

CALDER HALL COMES TO LIFE

When, on October 17, Her Majesty the Queen performs the ceremonial opening of the new atomic plant at Calder Hall, electric current will pass from the world's first full-scale nuclear power station into the grid. To commemorate this event—which is among the most significant of the century—we are publishing a series of three articles in which the Calder Hall station will be viewed from different aspects. In the first, which appears to-day, we present, as an introduction, a general picture showing broad features of the station and outlining some of the methods used in its construction. In the second we shall consider in more detail the engineering design of the plant and its principal components. The final article we propose to devote to the part played in building and installation by selected contractors and sub-contractors. In this way, we hope to underline the importance of the Calder Hall achievement, and to introduce the new source of power which on the seventeenth of this month will make its first full contact with the outside world. (*Reference to the Calder Hall project is also made in the leading article, and additional pictures of the power station appear on page* 421.)

On May 22 the first of the two reactors at the Calder Hall " A " atomic power station became critical. Since then both the reactor and its associated equipment have been subjected to comprehensive testing and trial running. In less than two weeks from now, when this period of gestation comes to an end, the plant will begin its active life, and power will flow from its orthodox steam turbo-generators into the national grid. However, the use of the word " critical " indicates that the plant itself is by no means orthodox, for it is a term with special meaning for nuclear engineers. It signifies the point during reactor start-up at which at least one neutron produced in fission of a uranium 235 nucleus causes fission of another similar nucleus and enables a chain reaction to proceed. In other words, the concentrations of fissile and absorbing material are such as to provide a dynamic equilibrium. Another term which is of importance is " moderator," since the Calder Hall reactors or piles are described as " graphite moderated." A moderator is a material which placed near or adjacent to the nuclear fuel slows down the neutrons emitted in fission so that they can more readily be " captured " by other uranium 235 nuclei, which, as a result, also undergo fission and produce further neutrons.

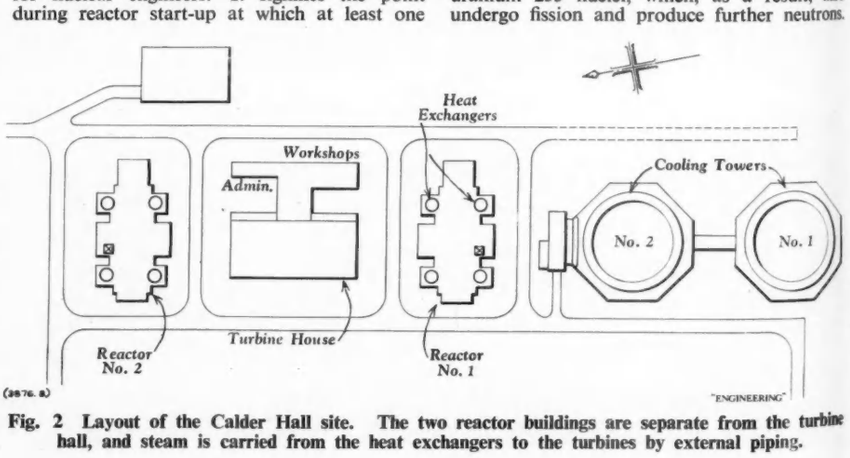


Fig. 2 Layout of the Calder Hall site. The two reactor buildings are separate from the turbine hall, and steam is carried from the heat exchangers to the turbines by external piping.

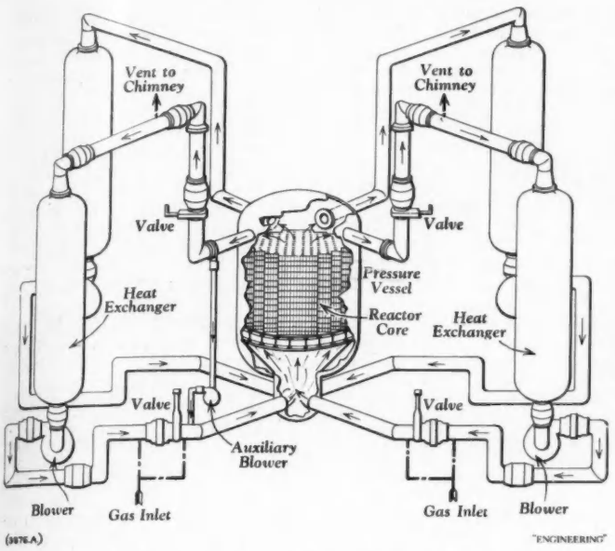


Fig. 3 Carbon-dioxide coolant passes through the reactor core, from which it carries heat to the heat exchangers. These generate steam to drive turbo-alternator sets. Considerable thermal expansion is likely to occur in the ducting between the reactor pressure vessel and the heat exchangers during certain operational changes and bellows are therefore included in the gas circuit.

The moderator thus assists in maintaining the chain reaction. It should be noted, however, that in the case of the Calder Hall reactors, neutrons will be expended not only in promoting fission and in parasitic absorption or loss outside the reactor core, but also in usefully converting uranium 238 (which comprises approximately 99·3 per cent. of the natural-uranium fuel) into plutonium. This, like uranium 235, is a fissile material and its production is in fact the main purpose of the Calder Hall plant, with power as a by-product. The disintegrating uranium 235 nucleus yields not only neutrons (some 2·5 per fission) but also its constituent fragments, which, dispersing with considerable kinetic energy, contribute the major part of the reactor's thermal output. The neutrons released also possess kinetic energy and in addition some gamma radition is emitted. The kinetic energy of the various products appears as heat, and it is this heat which is converted into electric power.

The reactors, in which the heat is produced, and the turbo-generators, which finally convert it into electrical energy, are housed in separate buildings, linked only by piping. This arrangement can be seen from Fig. 1, which is a general view of the station, showing the turbine hall and one reactor building, and Fig. 2, which is a simplified site plan. A gas—carbon dioxide—passing through channels in the hot reactor core carries the heat to heat exchangers (four per reactor) where steam is raised to drive the turbo-generators. The arrangement of a reactor and its associated heat exchangers (which correspond to the boilers of a conventional thermal power station) is represented in Fig. 3. Each of the four alternators is capable of generating 23 MW of electricity, giving a total maximum output of 92 MW. Of this, part is used to meet plant requirements, but a net output of 60 to 65 MW should be available for the national grid.

We have now referred to all the main factors defining the general design of the station and of the reactor itself, which is based on the gas-cooled graphite moderated system, known in this country as PIPPA. In addition, the fuel is natural uranium, as distinct from a uranium fuel enriched beyond the natural 0·7 per cent. in the fissile isotope uranium 235. Other features, important but not so fundamental, are the vertcial arrangement of the fuel channels in the graphite-moderator matrix, the use of fuel elements in the form of uranium rods, the introduction of control rods or neutron absorbers to govern the reactivity, the provision of shielding to protect operating personnel, and the need to enclose the reactor in a pressure vessel, since the carbon-dioxide coolant circulates under pressure (about 100 lb. per sq. in.) These will be dealt with in turn.

For simplicity we shall consider only one reactor, since the two are generally similar, and follow the route taken by the coolant in its closed circuit round the system. After passing through the reactor, where it must keep the fuel-element cans below 400 deg. C., the hot carbon-dioxide coolant leaves the top of the pressure vessel through mild-steel ducts 4 ft. 6 in. in diameter and flows to the four vertical heat exchangers situated at the corners of the reactor building. Passing down the heat exchangers and out at the base, the cooled gas enters four main blowers, which keep the gas in circulation. The gas then returns to the inlet manifold at the base of the pressure vessel. Motor-operated isolating valves of wedge-gate pattern are included in both upper (hot) and lower (cold) ducts, and flow cascades are fitted at the bends. Considerable thermal expansion is likely to occur in the ducting between the pressure vessel and the heat exchangers during certain operational changes, and to accommodate the resulting dimensional variations hinged bellows are included in the gas circuit. The bellows, which are of welded steel plate, provide flexibility in the ducting, while the thrust due to the internal pressure of the gas is taken by a pin joint in the bellows assembly. The entire duct structure is carried on sprung constant-load supports.

The four carbon-dioxide coolant blowers, one of which is illustrated in Fig. 4, are of single-stage centrifugal design with an overhung impeller. This impeller arrangement calls for only one gland and also permits the location of gland and bearings in such a way that access to them may be obtained without exposure to radiation above tolerance level. The gland is of face seal pattern. The coolant mass flow is controlled by adjusting the rotational speed of the blowers and not by varying the static pressure of the system as a whole. The blowers are driven by direct-current motors, developing from 1,800 to 2,000 h.p., which are supplied from motor generating sets in the blower house; Ward Leonard control permits blower speed to be varied over a range of 10 : 1.

About 2 per cent. of the mass flow ghrough each blower is taken from the downstream side, filtered and re-introduced on the up-stream side, so as to prevent the accumulation of graphite dust and iron oxide in the coolant system. Alumina drying units are employed to limit the water content of the coolant, and this is constantly checked, while in addition the gas stream is continuously monitored as a means of detecting burst fuel elements. Precipitor units form a part of the detection or "sniffer" apparatus. More than 20 tons of carbon dioxide are required to fill the reactor and coolant circuits, which are first exhausted and then supplied with gas from four liquid-carbon-dioxide storage tanks. Purging by repeated charging and discharging is necessary in the first filling.

Having outlined the coolant circuit, we can now discuss some of its components in greater detail. The pressure vessel is a near cylindrical shell of 2 in. welded steel plate, about 40 ft. in diameter and approximately 60 ft. high. Fabrication was carried out on site, with all parts except the inlet manifold arriving piecemeal. Extensive site welding facilities were set up and the vessel was built in five main sections, namely, the bottom dome, two parallel centre sections, an item known as the diagrid, and finally the top dome. A view looking down into the vessel during construction, showing the diagrid, appears

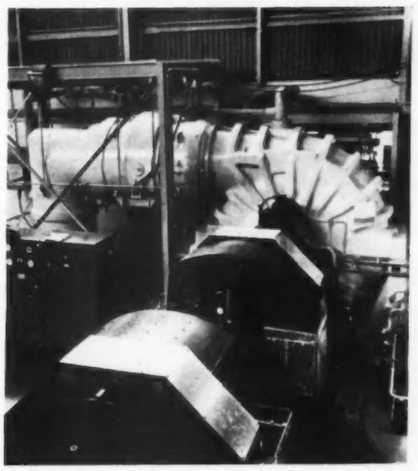


Fig. 4 Each reactor has four centrifugal coolant blowers (one per heat exchanger) which circulate the gas at 100 lb. per sq. in. round a closed system.

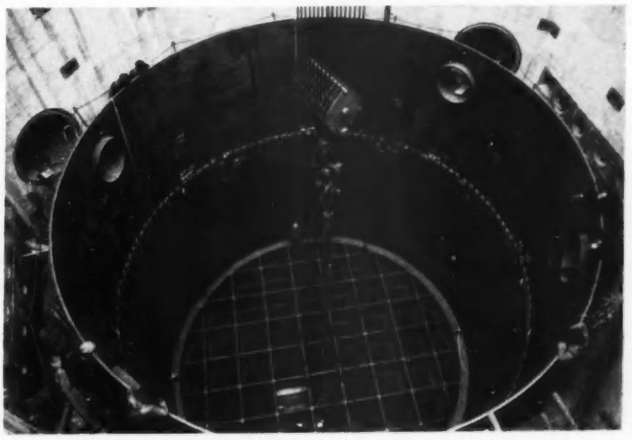


Fig. 5 Reactor pressure vessel during construction, showing the diagrid which supports the graphite moderator. The pressure vessel was fabricated from 2 in. steel plate and the final welds were completed on site. Part of the shielding can also be seen outside the vessel.

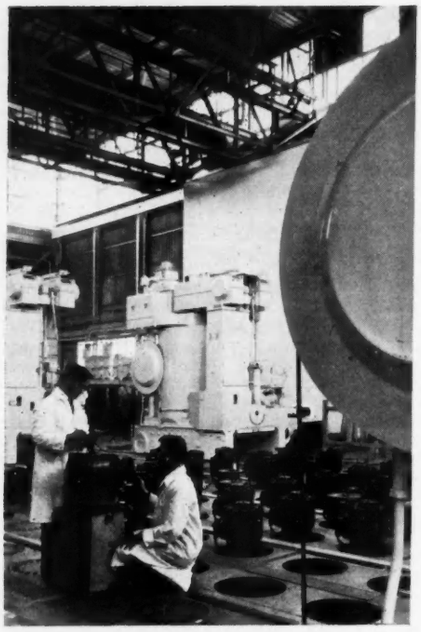


Fig. 6 Pile vault roof from which charging and discharging of the reactor are carried out by means of special machines. A discharging machine and a charging machine (left) can be seen.

in Fig. 5. Stress relieving was effected by radiant heating, requiring a peak electrical load of 1½ MW. The vessel temperature was raised to over 550 deg. C. and held there for 8 hours before being allowed to cool slowly and evenly.

The pressure vessel contains the reactor core, comprising fuel and moderator, which is about 21 ft. high and 31 ft. in diameter, and produces some 180 MW of heat. The moderator weighs more than 1,000 tons and is a structure of machined graphite blocks (about 60,000) containing some 1,700 vertical fuel and control-rod channels. Vertical channels were adopted to simplify the graphite structure and also the design of the coolant circuit. The weight of the graphite is borne on the diagrid, which consists of an I-section ring girder spanned by straight steel girders forming a rectangular lattice, as can be seen from Fig. 5. Across the members of the lattice are bolted 4 in. thick steel baseplates containing holes which coincide with the channels in the graphite. The baseplates support the moderator through a number of races which permit differential thermal expansion of the graphite and diagrid. The diagrid and moderator are supported by brackets passing through the walls of the pressure vessel on to ten inverted A-frames which rest on the reactor's thermal shield. These A-frames are loosely bolted both to the thermal shield and to the brackets on the pressure vessel. The three contact surfaces are radiused. In this way allowance is made for radial thermal expansion of the pressure vessel and diagrid; when expansion occurs the A-frames roll slightly out of vertical, while the bolts ensure that the rolling surfaces do not slip.

Charging and discharging of the reactor are carried out from the pile vault roof, which is shown in Fig. 6, where a discharging machine and other equipment can be seen. Reactor control and shut-off gear are also located in this area. It may be observed that the discharging machines are bulkier than the corresponding charging machines, which require less shielding since the unused fuel elements are negligibly radioactive, whereas the fission products which are formed in the fuel elements during operation present a considerable hazard. It is worth noting that many of these radioactive fission products can be separated and put to use. They are therefore a third product of the Calder Hall station.

Emerging from the reactor top dome are the charging tubes, which terminate at the upper surface of the pile vault roof. An overhead crane lowers the charge chute into the selected charging tube, and a charge machine supplies fuel elements, which are canned uranium rods 3 ft. 4 in. long and 1·15 in. in diameter, from a magazine. Conversely, a discharge machine removes spent fuel elements by withdrawing them up the charge chute and placing them in a basket where they can be kept cool. The basket is lowered into a coffin at the bottom of the discharge well; the coffin lid is automatically placed in position and the coffin transported to the cooling pond.

Control of the reactor is by means of long rods which when inserted into channels in the reactor absorb neutrons, thereby reducing excess reactivity; removing them has of course the reverse effect. Shut-off in the event of an emergency due to a fault or incorrect operation is achieved by means of a magnetic clutch in the control-rod support, which on the occurrence of irregular conditions is automatically demagnetised, so releasing the full length of the control rods into the reactor core. The control and shut-off rods, which are made of stainless-steel tubes lined with boron steel fillers, fall into two groups, coarse and fine. The coarse rods are used for major alterations in neutron flux, as for instance in start-up or shut-down, while the fine rods mainly serve to give control over minor fluctuations occurring during steady running. These rods are suspended through the charge tubes on a wire which is carried on a drum driven by an electric motor.

We have already referred to some of the precautions taken to ensure the safety of the station—the shut-off rods and the coolant-gas radioactivity monitors are two examples—but so far we have not described the means by which operating personnel are protected from the dangerous radiation which a reactor emits and which is injurious to living tissues and can often be lethal. The reactor is surrounded by a concrete "biological" shield seven feet thick. It is octagonal in form and is protected from heat and radiation effects by a thermal shield made of 6 in. mild-steel plate. It is on this shield that the A-frames previously mentioned rest. Induced-draught air cooling is supplied to the space between the two shields, and the outlet air is exhausted 200 ft. above ground level from the two stacks on the reactor building. The entire reactor including shielding and heat exchangers rests on a concrete raft 11 ft. thick and 130 ft. by 104 ft. in area, capable of supporting 22,000 tons.

We have now dealt briefly with the reactor and its associated equipment, and may thus follow the carbon-dioxide coolant to the next item in its route. Each of the four heat exchangers, which are contained in vertical steel pressure shells of 1 $\frac{5}{16}$ in. steel plate, is about 18 ft. in diameter and nearly 80 ft. high. One of the heat exchangers is shown being lifted into position in Fig. 7. There is approximately 30,000 sq. ft. of heating surface formed by steel tubing 2 in. in overall diameter, and comprising high-pressure and low-pressure economiser, evaporator and superheater sections. The water and steam pass through, and the hot gas over, the tubes, the surface of which is extended by use of elliptical steel stud tube fin construction. Flow in the evaporator sections is achieved by forced circulation from electrically driven pumps, which maintain a circulation rate of about four times the steam output of the section. Each evaporator has a single steam drum 4 ft. in diameter and 18 ft. long, which contains conventional cyclones and scrubbers.

As in the case of the reactor pressure vessel, the final assembly of the heat exchangers was carried out on site. Each heat exchanger arrived in nine main sections consisting of the dished ends, six cylindrical centre sections and the skirt. After assembly and inspection, the final welds were stress relieved by inductive heating. The heat exchangers were then lifted on to their concrete plinths by a pair of 100 ton gin poles.

We now leave the coolant circuit to follow the path taken by the steam and water. The steam passes to the generator house, situated between the pile buildings, where four turbo-alternator sets are installed. The turbines are two-stage reaction machines of established design. The low-pressure stage has twin exhausts which discharge into a surface condenser operating at 1¾ in. mercury absolute pressure. The condensate is passed through a de-aerating plant and the steam cycle is completed by high-pressure and low-pressure feed pumps which return the water to the economisers. Each turbine is directly coupled to an air-cooled alternator of standard pattern operating at 3,000 r.p.m. and having a continuous maximum rating of 23 MW at 11 kv. Power will be delivered through conventional transformers, switchgear and transmission equipment to the Central Electricity Authority's grid lines.

A separate dump condenser is provided in which up to the full-load steam production of the heat exchangers may be condensed without passing through the turbines. The condensate from the dump condenser is mainly for use during start-up and shut-down of the plant, but if required it will permit the reactors to be run at full load for plutonium production if the turbines are taken out of commission. A closed-circuit cooling water system is employed for the condensers, with four electrically driven pumps of 640 h.p. each and two natural draught cooling towers. The cooling towers, which are somewhat larger than normal being 290 ft. high and 220 ft. in diameter at the ring beam, are each capable of cooling 3 million gallons of water per hour by 10 deg. C.

Separate control rooms are provided for the alternators and electricity supply, and for the reactors, the reactor control room being equipped with a variety of monitoring instruments and recorders, including an indicating diagram of the reactor cross-section.

(The sources of the material used in this description will appear at the end of a second article, in which the general picture given here will be expanded.)

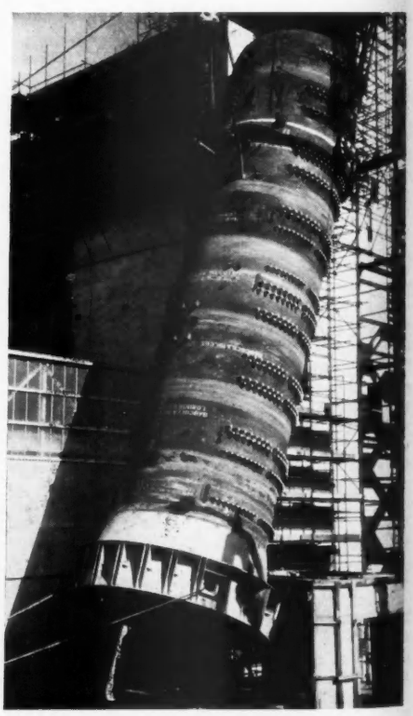
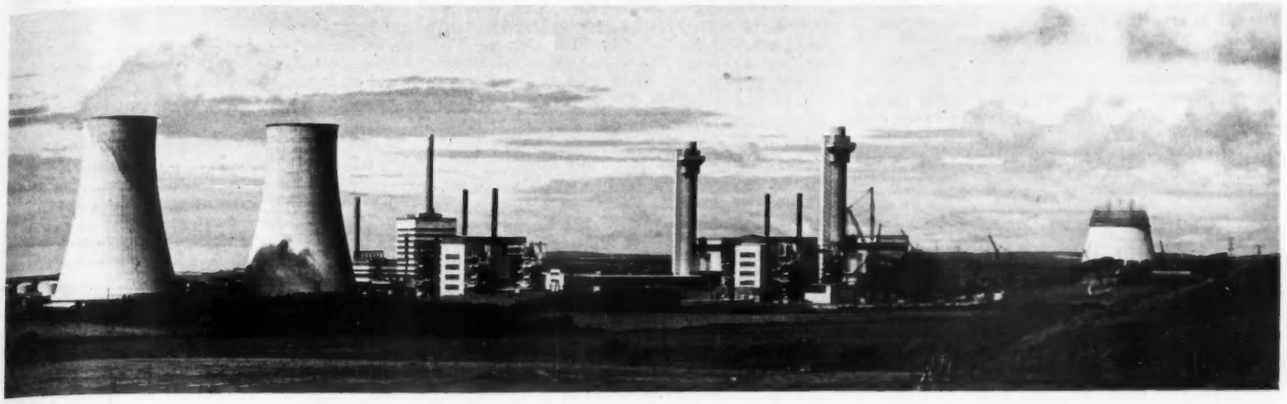
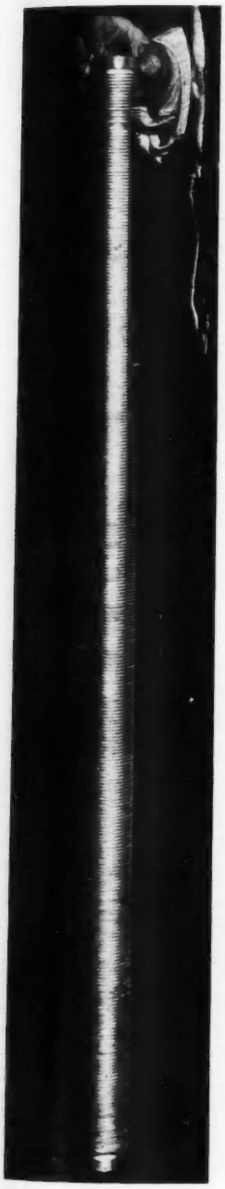


Fig. 7 The problem of lifting the heat exchangers into position was a major one, since they are nearly 80 ft. high and the empty shells weigh 200 tons.

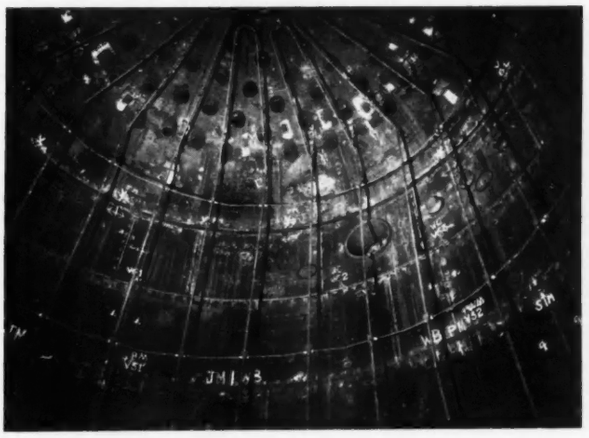
PICTURES OF CALDER HALL NUCLEAR POWER STATION



The Calder Hall "A" nuclear power station has been built on a site near the coast not far from the Windscale plutonium factory in Cumberland.

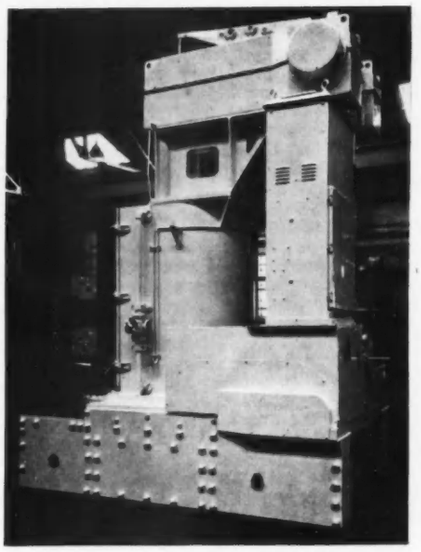


A fuel element (left) for the Calder Hall station, comprising a natural uranium rod canned in aluminium alloy. Extended surface assists heat transfer to the carbon-dioxide gas coolant.



Interior of reactor pressure vessel during stress relieving. The vessel, which was heated electrically, was held at a temperature of over 550 deg. C. for 8 hours before being allowed to cool slowly and evenly. The pressure vessels for the two reactors were fabricated from 2 in. thick steel and were designed to contain a pressure of 100 lb. per sq. in.

Reactor control room (above) for the No. 1 reactor. Comprehensive monitoring devices and automatic control gear simplify operation of the reactor and ensure safe and steady running.



Charging machine for inserting fuel elements into the reactor. Charging and discharging are performed by machines located on the pile vault roof, which move into position over the fuel channels.

Battery of precipitators forming part of the burst-slug detection gear—one of many safety devices.

Weekly Survey

Cover Picture: *This week's picture shows resistance coils being mounted on to the switch assemblies of a vernier potentiometer. The operation consists of silver-soldering well-aged coils of Manganin wire to the copper tags of potential switch assemblies, the latter forming part of a precision three-range vernier potentiometer measuring down to 1/10 microvolt. After soldering, the voltage drop across each resistance is carefully measured and metal removed by a small grinding tool until each resistance has an identical value.*

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Asian Industry Gathers Momentum

In many ways, South-East Asia has been fortunately placed in the last decade so far as increased industrialisation is concerned. The World Bank has been acutely aware, partly for political reasons apparent enough in the United States, of the need to help to finance sound projects for providing cheaper power and better communications for industry. The various agencies which have been established, of which the participating countries in the Colombo Plan are an example, have been able to work satisfactorily with local governments and organisations and most of the countries concerned have enjoyed reasonable prosperity. These favourable factors have combined to provide a much greater measure of industrial expansion than even some of the optimists had dared to hope. There have even been welcome signs of co-operation in economic development among certain countries and, by and large, the chief brake on expansion has been a lack of skilled manpower rather than shortage of money or enthusiasm.

All conceivable combinations of international co-operation have been used. At one extreme there have been such large individual contracts as the arrangement between the United States and Indonesia for the latter to buy American surplus farm products with Indonesia's currency which will be loaned back to that country to finance long-term economic development. At the other, there have been small gifts such as the New Zealand Government's offer of £50,000 worth of equipment to help the pasteurised-milk scheme in Ceylon. In between these, there have been loans by the World Bank, special credit arrangements for the payment of capital equipment and a number of grants in the form of money or equipment under the Colombo Plan itself. These gestures from outside have been used to supplement (sometimes it has been the other way round) plans for industrial development financed with local resources.

The Indian Government, whose second Five-Year Plan has been commented upon in ENGINEERING recently, intends to assume increasing responsibility for industrial development, and in the current financial year plans to invest £240 million in capital expenditure. Pakistan also mooted a Five-Year Plan in May this year to cover the period 1955-1960. In the smaller countries of Asia, there is the same story of self-help. In Ceylon, £16,500 has been provided direct for industry, and, in Malaya, further grants have been made out of the £32 million scheme, approved in May, 1955, for rubber replanting and development. Brunei requires no external aid at all, since revenues received by the Government from the British Malayan Petroleum Company, Limited, which operates the profitable Seria oilfields, have provided sufficient to finance Brunei's £117 million Development Plan for 1954-58, without recourse to the World Bank or any other external agency. In Burma, the Ministry of Industry intends to open an Industrial Bank before the end of 1956, to provide loans and services to industrialists who require help, while in Cambodia a £36-million two-year investment plan has been published as a prelude to a larger four or five-year plan. Nepal's Development Plan envisages an investment of £15·8 million for the five-year period from July, 1956, and, in Indonesia, a Five-Year Plan will soon be presented as a draft Bill. In Thailand, the National Assembly has passed a Bill to float a £57 million loan for economic projects. Five-Year Plans are certainly fashionable. It remains to be seen if they are all successful.

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Twilight of the Trolleybus?

Supporters of electric road traction had foreseen a renewal of interest in the trolleybus as a result of the Suez situation and its possible effect on oil supplies. Last Friday's announcement by the London Transport Executive, that 850 "Routemaster" buses have been ordered as a first stage in replacing, early in 1959, some 1,500 trolleybuses shows that world events have not yet brought a change of policy at the Executive headquarters. In Glasgow, however, a Corporation meeting last month defeated a motion to scrap the tramways entirely, on the grounds of prudence in conserving oil resources and looking ahead to cheaper electric power through atomic energy. This city has a mixed trolleybus and Diesel bus programme in hand, the future development of which in deciding the proportion of each type of vehicle to use in replacing tramway routes may be influenced by world events.

In spite of its uncertain prospects at home, the trolleybus has benefited greatly from various technical improvements in the post-war years. Automatic acceleration is now general, the various schemes being arranged so that, however the driver operates the pedal, the controller will not "notch up" so rapidly as to trip the circuit breakers in the bus. Oil-dashpot and eddy-current brake systems are used for retarding the controller action, and a recent development has been a pendulum relay which governs the controller action in a manner reminiscent of the inertia control of the braking effort in Underground trains. In all these systems, drivers can use their own skill in notching up if they prefer, as they have been used to do with non-automatic control, for, when the pedal is depressed at a rate appropriate to road conditions, the controller follows it without retardation and the passage through the various notches can be felt by experience in the driving seat.

Rheostatic braking has been improved by the evolution of circuits to provide constancy of effort over a wide speed range and avoid damage to the transmission by over-torque. One system developed recently claims a greater independence than hitherto between motor temperature and braking effort, so that higher average efforts can be employed without excessive peaks occurring in cold motor conditions. Electric braking is linked with the air brakes, both being operated from the same pedal, so that two-pedal control—a new feature in some oil-engined commercial vehicles this year—is inherent in the trolleybus. The interest of oversea operators in trolley-buses continues to stimulate progress in technical design. It would be optimistic, however, not to note that although a home market in railway-traction equipment is opening up for the electrical industry, so far, there has been no firm sign that trolleybus opportunities will not dwindle.

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Two Million Villiers Engines

The Villiers Engineering Company, Limited, Marston-road, Wolverhampton, was founded in 1898, to manufacture cycle pedals, but after a few years this product was abandoned in favour of the free-wheel for which the company have since become world-famous. Forty-four years ago another decision which was to have equally far-reaching effects was taken: the company entered the lightweight internal-combustion engine field. The first engine was a four-stroke model, with an integral clutch and gearbox, which was rejected by the British motor-cycle industry as being "too advanced" in design. It was followed by a two-stroke engine, which gradually achieved popularity, and was the first of a series of engines with which the company once again took its name to all parts of the world. Much of the subsequent history of the Villiers engine is well-known, as is the pioneering work of the company with carburettors and flywheel magnetos, and the name Villiers is now, of course, as celebrated in the engineering world as a source of power for machinery as it is among the motor cyclists as the power unit of more than 75 per cent. of British two-stroke machines.

The work done by the company in the motor cycle and industrial fields during the last 44 years was marked recently in a pleasant little ceremony at the Wolverhampton works, when the two-millionth engine came off the assembly line. The engine, a Mk. 1H, 225c.c. model, was formally presented to the Science Museum, London, by Mr. H. Geoffrey Jones, joint managing director of Villiers, and accepted on behalf of the Museum by Mr. C. F. Caunter, assistant keeper. The engine was then taken to the test house, where it was given the standard test of one hour's duration which all Villiers engines have to pass, and it was fitted to a Francis-Barnett Cruiser motor-cycle frame. The engine will be displayed in showrooms and at the Cycle and Motor Cycle Show at Earl's Court, and finally it will be sectioned and handed over to the Science Museum for permanent display.

The choice of a motor-cycle unit as the two-millionth was deliberate; for although Villiers have for many years made a large range of industrial engines, both two-stroke and four-stroke, the first engine made by the company was for a motor cycle.

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World Bank Report

The International Bank for Reconstruction and Development had an active year, according to the report now available for the 12 months ended June, 1956. Total lending was down slightly, compared with 1954-55, but the global loan figure was nevertheless as high as 396 million dols. Mr. Harold Macmillan, the United Kingdom Chancellor of the Exchequer, delivering his presidential speech to the Bank in Washington last week, referred to the levelling up in the standards of living which could be expected as more capital was induced to flow into backward areas. The World Bank has certainly begun to play an important part in bringing this about.

Power projects, in particular, have benefited from the attentions of the Bank. This is not surprising for most backward areas are prepared to put their own money into providing cheap power for industry. Last year such grants accounted for 50 per cent. of the total loaned by the Bank, and one of them, the 80 million dol. loan for the Kariba power project, was the largest made by the Bank until the present for any single scheme. A sum of 27 million dols. was also provided for a combined hydro-electric and irrigation scheme. "The Bank" said Mr. Macmillan, "has helped to finance new generating capacity producing more than twice the total electricity output of Brazil or India." Industry also benefited in many countries. Of a total of 93 million dols. granted for industrial purposes last year 75 million dols. were lent to the Tata Iron and Steel Company of India, the largest loan ever made by the Bank to industry. Meanwhile, to develop transport, loans totalled 127 million dols. last year.

Such statements and such figures are impressive. The share of the ensuing contracts which British industry has won is less so. A table in the annual report shows expenditure by borrowers on imports from various countries. It thus gives some indication of the extent to which

these countries have been successful in their tenders for heavy-equipment contracts. Figures from one year to another are influenced by the incidence of particular large contracts but the picture, from this country's point of view, is not particularly reassuring. It is very apparent that while the share taken by the United States has not changed a great deal, Germany has gained at the expense of the United Kingdom—and so has Canada. Germany, incidentally, is now releasing substantial sums in its own currency for the Bank to loan—this kind of finance being the main source of the Bank's loanable funds.

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Increased Aircraft Exports

For the first eight months of 1956 the British aircraft industry exported £73 million aircraft, aero-engines and parts. This was £7 million more than for the same eight months of 1955, thus establishing a new peak. It is notable too that the United States is currently a major market thanks to the success of the Viscount. There is every indication from the order book that this excellent performance will be kept up. The picture is encouraging. It is also patchy.

Certainly British producers of short and medium-range aircraft are doing well. During the first eight months of this year, sales of Viscounts alone were over 35 per cent. of the aircraft industry's exports. In the really short-range class, sales are as yet not significant but the Scottish Aviation Twin Pioneer is said to have aroused considerable interest overseas, while the Auster Agricola also promises to sell well. It is reported that negotiations are "well advanced" to sell more than 100 of these versatile planes at a value of around £1 million. Less has been heard this year about the Handley Page Herald after its initial success in 1955, but the order book last year, at around 35 aircraft before full-scale production had been started, gives some idea of the need for this type of aircraft.

In the field of the larger airliners, however, the British record is not so good. Despite the fact that Capital Airlines have ordered 14 Comet 4s, and Canadian Pacific Airlines five Britannias, these are small compared with the orders for the Boeing 707 or the Douglas DC8. Britain's brightest current hope appears to be in supplying the jet power plant rather than the complete aircraft. Trans-Canada Airlines, Lufthansa and Air India International Corporation are among the overseas buyers who have specified the Rolls-Royce Conway as the engine to be used in the American jet airliners which they have ordered. Overseas sales of British aero-engines during the first eight months of the year, at £18·2 million, account for 25 per cent. of the total export figure of the British aircraft industry in that period. Indeed, exports of aero-engines and Vickers Viscounts between them totalled about 60 per cent. of the aircraft industry's exports between January and August this year.

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The Price of Stable Prices

Instances of rising turnover and smaller profit margins have become so numerous in the last few months as to be the dominating trend in business experience. The undertaking by several large industrial groups to freeze their prices until varying times in 1957 is a guarantee that the trend will continue for some months. It is time to realise that this policy of halting prices while costs rise is a Fabian tactic having dire possibilities. The only justification for indulging in the hope that sitting on a problem will solve it is that certain quick reactions can be obtained. In this instance the justification for price stabilisation is that a temporary and judiciously timed voluntary price peg will persuade the unions not to demand higher wages. If the gesture fails the position could well be worse than before it was made.

Some of the complications which may arise can be seen in the annual report of the Central Electricity Authority, issued recently, and to a less extent in the half-yearly statement put out by Imperial Chemical Industries Limited last week. In both cases turnover has increased and gross profits fallen. The C.E.A. report is quite categorical that the decision to stabilise tariffs until March, 1957, will "seriously reduce the industry's financial working margin" and, in fact, involve certain areas in a deficit. This state of affairs is being imposed upon a nationalised industry which has all along calculated its depreciation charges on historical costs. There is clearly a serious risk in allowing the electricity industry to reduce its financial provision for new and replacement equipment when it faces a long-term upward trend in activity accompanied by the introduction of revolutionary techniques, especially as the financial provision already made can only be described as slender. If the industry's costs do not lose their present momentum, and the least sign that could be accepted that this was happening would be a successful policy of wage restraint in industry as a whole, the industry will be under severe pressure to raise its tariff steeply next year and gradually accept a growing interest charge on large sums borrowed from outside because it cannot finance expansion from accumulated profits.

In the case of I.C.I., the net income for the half year to June, 1956, was reduced from £12 million to £10·4 million. There is no indication from the statement that the board is as yet unduly concerned with the effect of falling profit margins on the replacement of equipment but there is no doubt that the fall has been due to increased costs not being offset by higher prices. It is apparent however, that even for a concern as large and as financially impregnable as I.C.I. there is a limit to the reduction in margins which can be tolerated without making recourse to the general public for money.

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Electricity Tariffs

The publication of the eighth annual report of the Central Electricity Authority, to which we referred in the leading article last week, was as usual made the occasion of a Press conference at which Lord Citrine commented on a few points of current and future interest. Among other subjects he referred to the Calder Hall nuclear power station, which he suggested would introduce a new power era, and expressed the hope that work on the Bradwell and Berkeley stations would begin early in 1957. Subsequently the question of electricity prices arose.

In his opening remarks Lord Citrine had already recalled that the Herbert Committee had advocated increases in order to enable the Authority to finance its constructional programmes out of revenue to a greater extent. While accepting this view the Authority had, however, not been able to implement it, as this would have meant raising prices when the Government were endeavouring to keep them down. In fact, as a consequence of an appeal by the Chancellor the Area Boards had been asked not to increase their prices at least until March 31 next year. This meant that in all cases their finances would be strained, although it was unlikely there would be a deficit for the supply industry as a whole.

Answering questions on this point he said that it would be wrong to suppose that the price of electricity would necessarily go up next year, although "whether we can afford to have a number of our Boards in deficit indefinitely is a very serious economic issue." Sir Henry Self, in his turn, pointed out that it had always been the policy of the Authority to provide for capital expansion out of revenue. To do this it would, however, be necessary to earn annual surpluses of £30 million or £35 million (instead of £12 million as at present). This would mean increasing tariffs by 7 or 8 per cent., assuming the increase was spread over all consumers.

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Titanium Production Costs

Detailed cost data on the production of titanium at the U.S. Bureau of Mines Boulder City (Nevada) plant have been published by the U.S. Department of the Interior (Bureau of Mines Investigation 5248, July, 1956). The plant, which operates the Kroll magnesium reduction process, has a capacity of 1,350 lb. of titanium sponge per day. It was constructed during 1952 with Government funds "to seek improvements in producing titanium metal." Production began in May, 1953, and ended in September, 1954, having yielded 492,503 lb. of acceptable sponge. The cost data given in the publication include a separate analysis of the cost of materials, direct and indirect labour, administration, maintenance, as well as the cost of the capital employed, subdivided into building and equipment items.

The overall cost during the 15 months of production averaged 3·609 dols. per pound of acceptable sponge, of which raw materials—titanium tetrachloride and magnesium—accounted for 58·25 per cent. and the cost of labour and supervision (exclusive of administration) for 19·3 per cent. The detailed analysis of direct operating costs and of the materials used are given for March, 1954, which was chosen as a representative month, typical of the seven months during which "production was stabilised and was not influenced by starting-up, expansion or closing-down factors." The average operating costs per pound of acceptable sponge were 3·196 dols., or 2¼ per cent. lower than the average for the full 15 months of operation.

While the detailed analysis cannot be presented in a note—a close study of the full text is suggested—certain salient features are worth extracting. Total expenditure on buildings, handling gear and utilities (water, power and gas) amounted to 265,627 dols. and that on process equipment and engineering design for the plant amounted to 409,834 dols. The depreciation costs of the buildings, spread over 20 years, averaged 3·37 cents per pound of sponge, and those of the plant, spread over five years, averaged 20·80 cents per pound. This compares with 2·174 dols. for raw materials and 63·8 cents for labour. Great care was taken that materials and supplies were purchased in the open market so that the cost data should be of maximum use as a guide to the titanium manufacturing industry. Labour costs were higher than would be expected in this country, and the quality of labour was probably lower—since the temporary nature of the scheme did not allow the recruitment of the best possible team. Forty-one men were employed on four shifts for round-the-clock operation. The total number of man-hours required per pound of acceptable sponge produced in March, 1954, was 0·198.

Other items given in the report include a description of materials used and time study data for major and minor unit operations, given separately, and a description of main jobs. While further progress has been made in the United States and in this country in production techniques, with reduction in costs, this report is the most comprehensive analysis published so far and a most useful guide.

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New Look at Singers

A new car in nine months is the first tangible result of the merger of the Singer Company with the Rootes group at the end of last year. If the Singer "Gazelle" is successful—and it would appear to have as good a chance as most other British cars—it will be a striking answer to those who criticised Sir William Rootes for taking over

a doomed company at a time when the British motor industry was facing a crisis. Appearances were certainly against him. Yet the Rootes group have performed during the past six months of crisis as well as their main competitors and better than some.

But there were very good practical reasons for the purchase: Rootes needed to become a larger manufacturing unit quickly, in order to compete with the giants of the industry; they have a large and lively sales organisation able to handle more than is produced in the group's factories and they have a drive and imagination in their top management few companies of their size can boast of. Finally, Singers were cheap at the price, particularly if the future of the motor industry was to be one of continued growth—as Sir William believed it was.

Singers had a poor name for small cars of high quality, but inadequate resources of finance and management were certainly a contributory factor in their falling out of the race. They needed complete re-organisation, but quick surgery was required if heavy losses or extensive lay-offs were to be avoided. Prices of existing models were slashed, and every effort was made to produce a new car to carry the name of Singer during the season of motor shows which begins in Paris this week. The Singer " Gazelle " has been designed with an eye for export markets. It embodies the Singer four-cylinder overhead camshaft engine and many of the body features of the popular Rootes models. The compression ratio has been raised to $7\frac{1}{2}$: 1, giving an increased output of 52·5 b.h.p. at 4,500 r.p.m. The basic price of the saloon models, £598, is competitive with cars in its class.

To produce a car in so short a time is a feat of engineering and organisation even if, as in this case, there was heavy borrowing from the features of the group's cars. It remains something of a gamble, but if successful, the purchase of Singer is likely to turn out one of the most profitable moves Sir William has made so far. The fact that he started his career with Singer—in 1912—may well have been an important factor in " the close and harmonious co-operation " which Sir William said made possible a strict adherence to an incredible time schedule.

* * *

Rover's Turbine Coupé

After six years of experiments, the builders of the world's first gas-turbine car have got close to the form they think the first saleable model might take—a high-speed coupé car with rear engine and four-wheel drive. The new coupé, to be shown at the London Motor Show this month, is not a production model but represents a big step towards one in terms of performance, appearance, fuel consumption and road behaviour.

Such a car could offer high performance at a premium price, but with fuel consumption comparable to that of fast piston-engined sports cars. With a 110 h.p. turbine, the Rover Company's T.3 goes from stand to 60 m.p.h. in 10·5 seconds and easily exceeds 100 m.p.h. Test figures obtained by Rover engineers at the M.I.R.A. proving ground show acceleration from 0 to 60 m.p.h. in $10\frac{1}{2}$ seconds and 0 to 80 m.p.h. in 18 seconds. The car has lapped the speed circuit at 102 m.p.h. with plenty of power in hand. Fuel consumption tests at steady speeds showed the following results: 40 m.p.h.—13·8 miles per Imperial gallon; 60 m.p.h.—14·3 m.p.g.; 80 m.p.h.—12·8 m.p.g. The turbine unit, mounted in the tail of the car, is less than half the size of that which powered the original gas-turbine car six years ago.

Air is taken through two filters mounted flush with the rear deck, and the exhaust is discharged upwards through a central outlet on the rear deck panel. Rover's claim that four-wheel drive is desirable to permit the high torque to be utilised safely. The drive passes down the reduction gear to the rear differential and forward under the floor, by a two-piece propeller shaft, to the front differential. Between front and rear there is a free wheel, as on the early Land Rovers, to prevent excessive torsional stress developing in the drive shafts in cornering. The rear axle is De Dion. This is the first Rover designed round a turbine; others have been adaptations of piston-engined cars. The result is a compact light car, without radiator, clutch or gearbox. Body panels are in resin-bonded glass fibre.

The engine has a single-stage centrifugal compressor with a maximum speed of 52,000 r.p.m. driven by a single-stage axial-flow turbine. A second-stage power turbine drives the car through a 7·45 to 1 reduction gear, plus the front and rear differentials. The reduction gear also incorporates a reverse, engaged by a central control lever. The heat exchanger is a plate-type secondary-surface contra-flow unit on top of the engine, using hot exhaust gas to heat the compressed in-going air before it reaches the combustion chamber. The exhaust emerges at about 200 deg. C.; the exit in the rear deck also functions as an ejector orifice to ventilate the engine compartment. The engine develops 110 b.h.p. at 52,000 compressor r.p.m. with a pressure ratio of 3·85 to 1. Maximum gas temperature to turbine is 830 deg. C. and the air mass flow is 2 lb. per second. Idling speed is 15,000 r.p.m. Starting is by 12-volt starter which turns the compressor shaft through a 10 to 1 step-up gear and is cut out by compressor pressure at the self-sustaining speed. The driver controls the engine solely by the accelerator pedal, which transmits motion hydraulically to a lever in the engine fuel system, varying the setting of the centrifugal governor. Should the unit fail to light up on starting, surplus fuel is drained from the combusion chamber and engine casing by an automatic air-operated valve to eliminate fire hazards. The driver has only two pedals, accelerator and brake. There are two levers, for hand-brake and reverse gear. Dials on the facia show jet-pipe temperature, compressor r.p.m., road speed, oil pressure, fuel level and dynamo output.

Rover demonstrated their first turbine car in March, 1950, and set the first turbine car speed records with it at 151 m.p.h. on the Jabbeke highway in Belgium in June, 1952. In 1953, Rover Gas Turbines Limited was formed to manufacture and market their industrial turbines, and during the past year a test and development programme was carried out with a Rover saloon driven by a turbine mounted at the rear.

Several problems remain to be solved before production can be considered, but the T3 represents an interesting progress report from the pioneers in the turbine car field.

* * *

Letters to the Editor

A FALSE RECORD?

SIR, There is much to be said for the view, which you express in your Weekly Survey of September 28, of Mr. Campbell's recent attempt on the water speed record, namely, that the rules acted harshly on him. It can legitimately be said that Mr. Campbell reached a speed of approximately 287 m.p.h. over a distance of one kilometre, and this, of course, is the real measure of his achievement. It is also true to say that he averaged 209 m.p.h. over two kilometres.

I still think, however, that the official speed of 225·63 m.p.h. is meaningless as an average speed, and that it is an inadequate figure for the minimum speed achieved on the first run; we know with certainty that it is much too low a limit for that run. Presumably the controlling body will ratify the new record; they can hardly change their rules retrospectively, but I hope that they can and will amend them to prevent the recurrence of such an unsatisfactory situation as exists at present. May I offer the following suggestion as a possible solution of the difficulty?

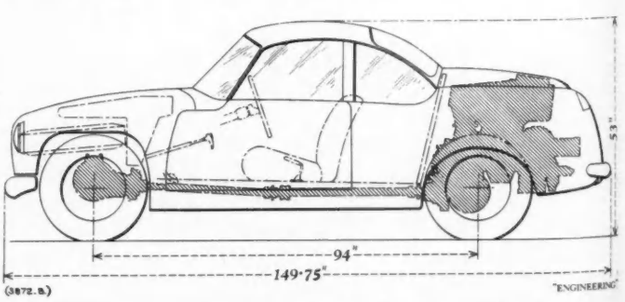
The arithmetic mean of the two speeds can give the average speed correctly only under conditions which are unattainable in practice, while the harmonic mean makes no allowance for the effects of wind and current. These effects are likely to be small. An attempt on the record can safely be made only in calm water, which implies almost windless conditions, or at worst light breezes. Mr. A. T. Walker, of Woolwich Polytechnic, has drawn attention to the surprising fact that the times are measured to the nearest tenth of a second only. Thus, even if there is no personal equation of the timekeepers to take into account, Mr. Campbell's speed on his first run may have been anywhere between 285 and 289 m.p.h. approximately. Thus the effect of the wind may well be within the experimental error in the timing. The current is also likely to be small, but it would be possibe to measure this at the time of an attempt on the record and then to correct the measured speed accordingly. A single run, if corrected in this way, would give a more realistic speed for the record.

If it is thought that this would open the way to boats of freakish design, which would be incapable of turning around and repeating their performance, the rules could require two runs as at present, both speeds being corrected for water current. The harmonic mean of these corrected speeds would then give an average speed which would be very close to the truth.

Yours faithfully,

R. G. HOWELLS.

Department of Physics,
University College,
Cardiff.
September 29, 1956.



The latest Rover gas-turbine car is a stage nearer production form.

VIEWER FOR INSPECTING BALLS AND ROLLERS FOR BEARINGS

FACILITATES INSPECTION FOR PRECISION WORK

Although, owing to the efficiency of modern production and inspection methods, the steel balls made for use in ball bearings, and for other technical applications, approach closely to perfection they may deteriorate to some extent in storage so that to meet the most stringent requirements it may be desirable to examine them for superficial blemishes before use. Inspection of the surface by ordinary means is difficult because a polished steel ball is a spherical mirror and small-scale images of surrounding objects appear on its surface tending to mask any defects, which are scarce and minute. The usual method of inspection is to employ a low-power hand magnifier or a lens of rather large diameter giving a magnification of two diameters, or even less, light being obtained from a window or lamp, but it is difficult by this method to see minute defects and distinguish pits, scratches or cracks from superficial dirt, specks of rust, smears, etc. Effective inspection, in fact, constitutes a somewhat difficult problem to which an interesting but fairly simple solution has recently been found by Mr. C. F. Smith, F.R.P.S., F.P.S., 1 Wood End-close, Farnham Common, Buckinghamshire, who manufactures the instrument used for the purpose.

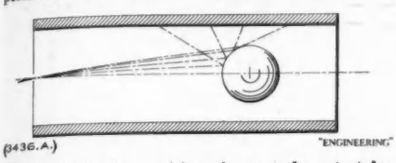


Fig. 1 Ball in position in translucent tube.

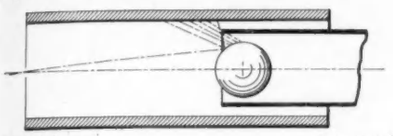


Fig. 2 Coaxial opaque tube added to give partial dark-ground illumination.

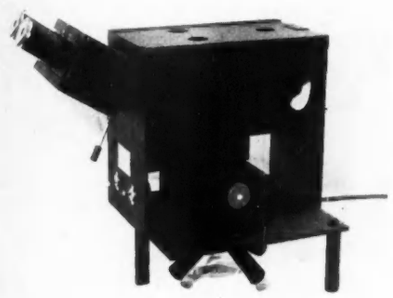


Fig. 3 View of complete apparatus.

The principle of the method is illustrated by the diagram Fig. 1. The ball is placed on the axis of a tube of translucent material, one end of which is closed by a diaphragm having a small central aperture. The tube is illuminated from the outside and when viewed through the aperture by eye, or by some telescopic system, the surface of the ball is seen by the light coming from various parts of the inner surface of the tube as indicated in the diagram. The surface of the ball is thus uniformly illuminated and dirt, dust or deposits proud of the surface are seen clearly. Scratches and pits below the surface, however, are not seen so well since they are illuminated by diffused light from the tube wall and the contrast is low. They can, however, be seen clearly and with good contrast if an opaque tubular screen is inserted between the ball and translucent tube, as shown in Fig. 2.

With this device the area under observation is limited by the edge of the tubular screen which gives dark ground illumination to the outer annulus of the ball. Light from the unscreened part of the translucent tube, however, enters the dark field and is reflected to the viewing aperture by the edges of any pits, scratches or roughness over an area near the edge of the shadow. For general scanning the screen is moved axially, or it can be left stationary in a mid position while the ball is rotated about a vertical axis at right angles to that of the tube either by hand or automatically; scratches and pits as well as dirt, etc., are then observed as they reach the edge of the shadow. An alternative screen with a deeply serrated edge is available which gives a larger area of dark ground observation. The viewing aperture is made as small as practicable to obtain ample depth of focus and also to make the direct reflection of the aperture which appears in the centre of the ball as small as possible; this reflection is unavoidable but the user soon learns to ignore it.

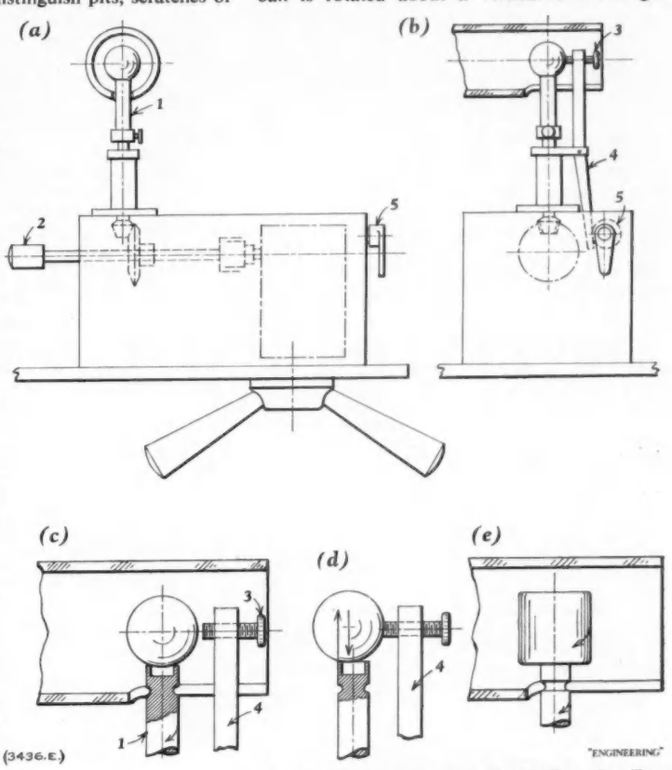


Fig. 5 Methods of supporting balls and rollers during examination.

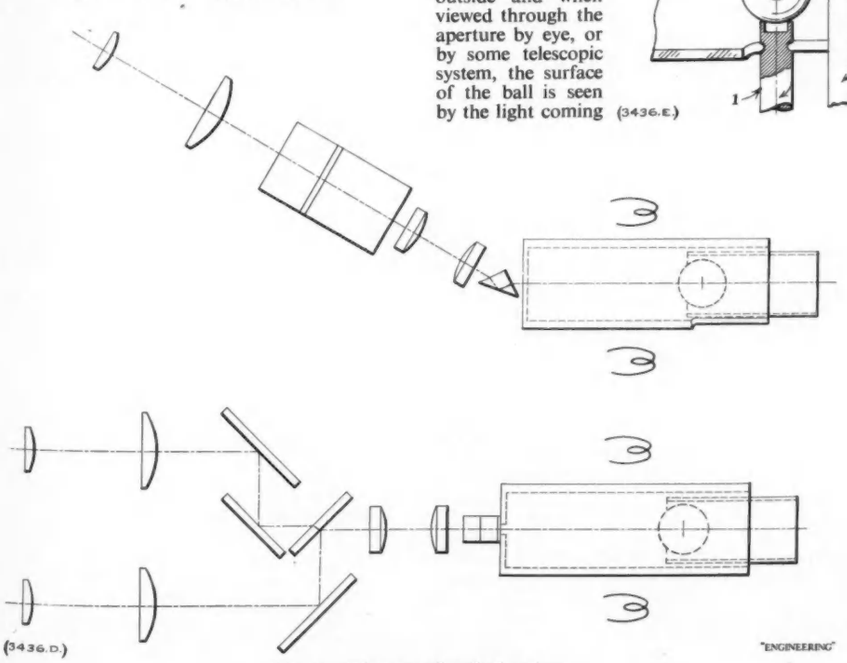


Fig. 4. Diagram of optical system.

Fig. 3 shows the complete apparatus as made up for binocular viewing and Fig. 4 illustrates the optical system diagrammatically. As will be seen, a small right-angle reflecting prism is mounted close to the viewing aperture to direct the light into an achromatic objective which is followed by a system of plane reflecting and semi-reflecting mirrors and a pair of wide angle eyepieces. Each eyepiece is mounted on a carriage with its nearest mirror and the separation need only be varied to suit the convenience of the viewer; the coincidence of the images is ensured by a works adjustment. The first model made is

designed to take balls up to $\frac{3}{4}$ in. in diameter and the field is large enough to cover the whole diameter at a magnification of eight diameters; for smaller balls alternative eyepieces are available for a magnification of 20 diameters. For illumination a number of 40 watt lamps are fitted round the translucent tube inside the casing.

It is, of course, necessary for the whole surface to be examined and the arrangements for enabling this to be done are illustrated in Fig. 5. As will be seen the ball rests on the recessed end of a vertical spindle 1 which is rotated at four revolutions per minute by a small synchronous motor, driving through a light friction clutch and a pair of bevel gears. The rotation of the ball may be stopped momentarily, slowed down or reversed as required, to enable some defect to be examined, by operating the handle 2, the motor continuing to run against the friction of the clutch while the handle is held and the normal rotation of the ball continuing as soon as the handle is released. Alternatively the motor can be switched off and the mechanism operated by hand.

It will be clear that since the ball rotates about a vertical axis and is viewed horizontally the whole of its surface is seen during one revolution except for the small area which rests on the spindle and the pole diametrically opposite this. To disclose these two areas to view, the mechanism shown in Fig. 5 (*b*, *c* and *d*) is provided. This enables the ball to be pushed forwards by means of a screw 3 fitted into the upper end of a pivoted lever 4 so that it is supported on one edge only of the rim of the spindle as shown in Fig. 5 (*d*). The point of support not being then in line with the centre of gravity, the ball will turn in a clockwise direction about a horizontal transverse axis, thereby exposing the areas previously hidden, and will continue to turn as long as it is displaced by the screw. The rate of rotation about the horizontal axis is approximately four revolutions per minute, so that if allowed to turn for four seconds the previously hidden parts will be moved through a right angle and thus brought on to the longitudinal axis of the tube. When the pressure on the screw is released by means of the cam lever 5 the ball will fall back to bring its centre of gravity into line with the axis of the spindle and will then rotate about a new vertical axis with the previously hidden parts in the best position for observation.

The apparatus can also be employed for examining the short stout rollers which are used for roller bearings and have a rectangular elevation not differing greatly from a square. These can be placed directly on the end of the spindle, as shown in Fig. 5 (*e*) or some simple form of adaptor may be used.

For loading purposes the ball mounting complete with the motor box is rotated by hand about the axis of the capstan type handle, thus bringing the parts within easy reach of the operator. Centring for each different size of ball is done by adjusting the height of the slider on the spindle 1 so that the horizontal axis of the ball is coincident with that of the screw 3.

The first model of the viewer, as illustrated and described in this article, is now being used by Bristol Aero-Engines Limited, and it is just possible that a few slight modifications may be made to future models as a result of the experience gained in workshop use.

A METHOD OF SAMPLE INSPECTION

By Margaret J. Baynton, D.I.C., A.R.C.S.*

As engineering becomes more complex there is a tendency for the amount of testing to be increased. A stage is soon reached when the testing of every component produced results in an extravagant use of time and manpower. Often failure in such tests does not necessarily mean that the product concerned is useless, but rather that, under certain conditions, its life may not be as long as that of one which has satisfied the test requirements. Accordingly, in an attempt to economise in manpower and testing time, the possibility of testing these products by a sampling scheme has been investigated.

For the purpose of this article a product which fails in any of the tests will be designated "defective," and the probabilities that one or more defectives will be accepted, if sample inspection is employed, have been calculated. The method used to calculate these probabilities is given in the Appendix.

The method of inspection suggested is based on a single sampling scheme. It requires that the products be divided into convenient batches, and a sample of suitable size be chosen from each batch. All the products in the sample are given all the necessary tests, and if no defectives are found the parent batch from which the sample was drawn is accepted without further testing. If, however, any one of the products is defective the complete batch is to be tested.

Double and sequential sampling schemes† were investigated, but were considered to be unsatisfactory for the present purpose. The main disadvantage found in them was that, although they resulted in a greater reduction in labour, this was not sufficient to justify the accompanying increased risk of accepting defective products. These schemes have been designed to protect the producer, that is, they guard against the rejection of too many non-defective products. This consideration does not arise here, since the choice is not between accepting or rejecting a batch, but between accepting it or testing all the products in it.

Very often the components are not all equally stressed when they are assembled in the final product, and various modifications of the basic probabilities are given to allow for this. These modifications take into account the position which the components will eventually occupy, and consequently the amount of work that will be required of them.

The results of the tests on a complete set of the components were available, and the suggested scheme has been applied to these results in order to demonstrate what might have happened had sample inspection been employed.

* The British Thomson-Houston Company, Limited, Rugby.

† In a double sampling scheme, a sample is drawn and tested as for a single sampling scheme. The requirements of the scheme lead to a choice between three decisions, according to the quality of the sample. These decisions are, accept the batch, reject the batch or draw another sample. If a second sample is drawn the decision between acceptance and rejection is based on the combined samples. In a sequential scheme the products are inspected item by item until some conclusion can be drawn, using a form of control chart.

BASIC SCHEME

Two alternatives have been considered:—

(*a*) Batch size = 50, sample size = 10;
(*b*) Batch size = 25, sample size = 5.

In each case the sample is to be chosen at random from the parent batch, using a table of random numbers, or some similar device.

In the discussion which follows, the number of defectives in a batch is represented by X. In practice, of course, X is an unknown quantity, but for the purpose of the calculations it is necessary to assume that it has a number of different values. Table I gives the probability that a batch containing X defectives will be accepted.

TABLE I.—*The Probability of Accepting a Batch Containing* X *Defectives*

X	*a* Batch size = 50	*b* Batch size = 25
1	0·80	0·80
2	0·64	0·63
3	0·51	0·50
4	0·40	0·39
5	0·31	0·29
10	0·08	0·06

To obtain a true comparison of the efficiency of the alternatives suggested they should be considered in relation to the percentage of defective products manufactured. Thus 10 defectives in 50, and 5 in 25, are both equivalent to 20 per cent. defective products in the complete set from which the batches are drawn. It is then immediately apparent from Table I that, whenever possible, batches of 50 should be used, since only 8 per cent. of such batches will be accepted compared with a 29 per cent. acceptance rate if the batch size is 25. For example, if 5,000 products are manufactured and 1,000 of them are defective, 80 defectives will remain undetected if they are sample-inspected in batches of 50; i.e., 8 batches will be accepted without further testing. If, however, batches of 25 are used, the probability is that 58 of the batches, or 290 defective products will be accepted. It should be noted, though, that using batches of 50 will involve more testing than using batches of 25, since more batches will need 100 per cent. testing.

ALLOWANCE FOR UNEQUAL STRESSING

As indicated in the introduction the component products will be differently stressed according to their final positions in the complete equipment. Thus it is important that certain positions should not contain components the tested properties of which fall outside the specified limits. Table II gives the probabilities that a defective component will be assembled in one of these critical positions, when using batches that have been sample-inspected and which contain X defective components.

In order to calculate these probabilities it has been assumed that one-fifth of the positions are critical, and that these positions are distributed throughout the assembly. Then if the components in any one batch are chosen at random, and assembled in a systematic order, we can assume that, on the average, one-fifth of them will be in critical positions.

TABLE II.* *The Probability that* y *Defective Components will be Assembled in the "critical fifth" when the Batch Used has Been Accepted and Contains* X *Defectives*

X \ y	0	1	2	3	4	5	6	7
	a. Batch size = 50, sample size = 10							
1	**0·80**	0·20						
2	**0·64**	0·33	0·03					
3	**0·50**	0·40	0·09	0·01				
4	0·40	**0·43**	0·15	0·02	→0			
5	0·31	**0·43**	0·21	0·04	0·01	→0		
10	0·08	0·27	**0·34**	0·22	0·08	0·01	→0	→0
	b. Batch size = 25, sample size = 5							
1	**0·80**	0·20						
2	**0·64**	0·33	0·03					
3	**0·50**	0·41	0·09	→0				
4	0·38	**0·45**	0·15	0·02	→0			
5	0·29	**0·46**	0·21	0·04	→0	→0		

It must be remembered that Table II applies only to batches which have been accepted by sample inspection, and that the probabilities given should be considered in conjunction with those in Table I. Thus, in order to obtain a true comparison between the risks involved in the

TABLE III.*—*The Probability that a Batch Containing* X *Defectives will be Accepted, and that* y *Defectives will be Assembled in the "Critical Fifth"*

X \ y	0	1	2	3	4	5	6	7
	a. Batch size = 50, sample size = 10.							
1	**0·64**	0·16						
2	**0·41**	0·21	0·02					
3	**0·26**	0·20	0·05	→0				
4	0·16	**0·17**	0·06	0·01	→0			
5	0·10	**0·13**	0·07	0·01	→0	→0		
10	0·01	0·02	**0·03**	0·02	0·01	→0	→0	→0
	b. Batch size = 25, sample size = 5.							
1	**0·64**	0·16						
2	**0·41**	0·21	0·02					
3	**0·25**	0·21	0·04	→0				
4	0·15	**0·17**	0·06	0·01	→0			
5	0·09	**0·13**	0·06	0·01	→0	→0		

* In Tables II-V the most probable event for each value of X is in bold type.

alternatives suggested, Tables I and II have been combined. Table III gives the probability of the simultaneous occurrence that a batch containing X defectives will be accepted, and that *y* defectives will be assembled in the "critical fifth," and it is applicable to all batches as they come off the production line.

Thus if we have 100 batches of 50 components each containing two defectives, a total of 25 defectives ($100 \times 0{\cdot}21 + 2 \times 100 \times 0{\cdot}02$), will be put in the critical fifth, and, from Table I, 72 defectives will be rejected.† The remaining 103 defectives will be distributed in the other four-fifths of the equipment. If, however, the same components are divided into batches of 25, there will be 200 such batches. Then, from Table III (*b*), there will be 32 defectives ($200 \times 0{\cdot}16$), in the critical fifth, 40 will be rejected and 128 will be distributed in the remaining four-fifths of the equipment.

THE SECOND FIFTH

In order to ensure that no defective components will be assembled in the "critical fifth" it is now suggested that all components which are inspected and found to lie within the specified limits should be given a distinguishing mark. Only those so marked are to be assembled in the critical positions, and since at least one-fifth of every batch is tested there should be sufficient to fill all the critical positions.

The most critical positions thus being protected, it is of interest to know what are the chances of defective components being assembled into one of the other sections of the equipment. We will distinguish this section as "the second fifth."

Two more sets of probabilities have been calculated, and are recorded in Tables IV and V. These tables are analogous to Tables II and III respectively, in that Table IV refers only to batches which have already been tested, and Table V refers to all batches as they come off the production line.

TABLE IV.*—*The Probability that y Defectives will be Assembled in the Second Fifth when there are X Defectives in the Remaining 40 (or 20) Untested Components*

X \ y	0	1	2	3	4	5	6	7
	a. Batch size = 50, sample size = 10.							
1	0·75	0·25						
2	0·56	0·38	0·06					
3	0·41	0·44	0·14	0·01				
4	0·30	0·44	0·21	0·04	→0			
5	0·22	0·42	0·28	0·08	→0	→0		
10	0·40	0·17	0·33	0·30	0·15	→0	→0	→0
	b. Batch size = 25, sample size = 5							
1	0·75	0·25						
2	0·55	0·40	0·05					
3	0·40	0·46	0·13	0·01				
4	0·28	0·47	0·22	0·03	→0			
5	0·19	0·44	0·29	0·07	0·01	→0		

TABLE V.*—*The Combined Probability that a Batch Containing X Defectives will be Accepted, and that y Defectives will be put in the Second Fifth, the Critical Fifth having Been Filled with Marked Components*

X \ y	0	1	2	3	4	5	6	7
	a. Batch size = 50, sample size = 10.							
1	0·60	0·20						
2	0·36	0·24	0·04					
3	0·21	0·22	0·07	→0				
4	0·12	0·18	0·08	0·01	→0			
5	0·07	0·13	0·09	0·02	→0	→0		
10	→0	0·01	0·03	0·02	0·01	→0	→0	→0
	b. Batch size = 25, sample size = 5.							
1	0·60	0·20						
2	0·35	0·25	0·03					
3	0·20	0·23	0·07	→0				
4	0·11	0·18	0·08	0·01	→0			
5	0·06	0·13	0·08	0·02	→0	→0		

Again considering the 5,000 components of which 4 per cent. are defective, and dividing these into 100 batches of 50, 32 defectives ($100 \times 0{\cdot}24 + 2 \times 100 \times 0{\cdot}04$) will be put in the second fifth. Dividing them into batches of 25, 40 defectives ($200 \times 0{\cdot}20$) will be put in the second fifth. These quantities could, of course, be reduced by assembling any surplus marked components in the second fifth.

* See footnote to Table II.

† The number of defectives which will be rejected may also be obtained directly from Table III. Thus, in the example quoted, the number of defectives rejected equals

$$2 \times 100\,[1 - (0{\cdot}41 + 0{\cdot}21 + 0{\cdot}02)] = 72$$

PRACTICAL EXAMPLE

A set of actual test results was divided into batches of 50 in chronological order, and 20 random sets of ten numbers between 1 and 50 were obtained by drawing numbers out of a hat. These sets of ten numbers were then used in turn to obtain a random sample of ten results from each batch of 50 results. The numbers of defectives in the sample and in the complete batch from which it was drawn were counted, and are recorded below (Table VI).

TABLE VI.—*Numbers of Defectives in a Sample of* 10 *Drawn from a Batch of* 50, *and in the Complete Batch*

Batch No.	No. of defectives in a batch of 50	No. of defectives in a sample of 10	Batch No.	No. of defectives in a batch of 50	No. of defectives in a sample of 10
1	0	0	14	0	0
2	0	0	15	3	0
3	0	0	16	2	0
4	5	0	17	0	0
5	5	0	18	2	0
6	0	0	19	1	0
7	8	2	20	1	1
8	2	1	21	0	0
9	11	2	22	1	0
10	8	1	23	1	0
11	1	0	24	2	0
12	0	0	25	2	0
13	1	1	26	2	1

Thus it would have been necessary to test 540 out of the 1,300 components, and of the 760 which were untested, 25 would have been defective.

These components contained about 4½ per cent. defectives, which is roughly equivalent to two defectives in a batch of 50. Thus theoretically about nine batches would have required 100 per cent. testing, compared with seven batches in practice, as given by Table VI. As, however, the defectives were not distributed evenly, with two in each batch, only 25 defectives escaped detection compared with the theoretical total of 34. Further, from Table V, we might expect that about nine defectives would have been put in the second fifth.

The suggested sampling scheme effects a considerable saving in testing time, which may be as much as 80 per cent. if the components contain only 2 per cent. defectives, while the quality of the finished product is not seriously jeopardised.

Appendix: Calculation of Probabilities

Since the batch sizes are small it is necessary to allow for the fact that the proportion of defectives in a batch is altered when one or more products are taken from it.

Then, the probability of accepting a batch of size N, by testing a random sample drawn from it of size *n*, is equal to the probability of choosing *n* "good" products from a total of (N—X) "good" ones, where X is the number of defectives in the batch. Hence, probability of acceptance $= \dfrac{(N - X)\,C_n}{NC_n}$, where $(N - X)\,C_n$ stands for "the number of ways of taking $(N - X)$ products *n* at a time," etc. This formula has been used to calculate the probabilities in Table I, with N = 50 or 25, and *n* = 10 or 5, respectively.

Similarly, when the batch has been tested, the probability of there being *y* defectives in any set of S positions is given by:—

$$\frac{(N - X)\,C_{(S-y)} \times C_y}{N\,C_S},$$

where $(N - X)\,C_{(S-y)}$ stands for the number of ways of taking $(N - X)$ products $(S - y)$ at a time, etc.

Substituting for N and *n* as before, and also giving S the values 10 or 5 as appropriate we can then obtain the values given in Table II. Table III can then readily be obtained by multiplying together the corresponding probabilities given in Tables I and II.

Example.—Consider a batch of 50 component products which contains four defectives:

$$\text{The probability of accepting the batch} = \frac{46\,C_{10}}{50\,C_{10}}$$

$$= \frac{46 \times 45 \ldots 37}{10!} \cdot \frac{10!}{50 \times 49 \ldots 41} = 0{\cdot}40 \text{ (approx.)}.$$

When the batch has been accepted, the probability of there being two (say) defectives in the first ten $= \dfrac{46C_8 4C_2}{50\,C_{10}} = 0{\cdot}15$. Hence the combined probability of accepting a batch containing four defectives, and of two of those defectives appearing in the "critical fifth," $= 0{\cdot}40 \times 0{\cdot}15 = 0{\cdot}06$.

The probabilities in Tables IV and V have been calculated in the same manner, but, since the ten (or five) "good" components which are tested are then marked and assembled in the critical positions, the undetected defective components are contained in the remainder of the batch, i.e., the batch sizes are reduced to 40 (or 20) for the purpose of the calculations.

Acknowledgement

The author wishes to thank the directors of the British Thomson-Houston Company, Limited, for permission to publish this paper.

LONG-DISTANCE RADIO IMPROVED

Ionospheric Scatter Equipment

As is well known long-distance radio communication, which is normally carried out in the high-frequency band, is faced with the difficulty that fading may occur at certain times, and that nothing can then be received at a given frequency for some hours. This difficulty can to some extent be overcome by switching to different frequencies at different times of the day. This complication is, however, if possible, to be avoided in practice, especially as sudden fluctuations in sunspot activity may simultaneously affect communications on all frequencies.

IMPROVED RELIABILITY

Considerable interest therefore attaches to an announcement by Marconi's Wireless Telegraph Company, Limited, Chelmsford, that they have designed an ionospheric scatter system of propagation in which very high frequencies are used, and which promises to overcome these difficulties. The importance of this is that while existing very-high-frequency transmission systems have a maximum range of 30 miles by making use of the ionosphere (and particularly of one ionised layer 50 to 70 miles above the earth) distances of 1,000 miles or more can now be spanned.

In this system very-high-frequency transmission is directed skyward at a critical angle until it meets the ionised layer. An appreciable fraction is then deflected forward and downward to reach the earth at a point about 1,000 miles from the transmitter, where it can be amplified and re-transmitted by a similar process for another "hop" or "hops" until its ultimate destination is reached. The system therefore provides a method of radio communication which can be carried on with a high degree of reliability throughout the 24 hours and all the year round. It is virtually unaffected by magnetic disturbances and is therefore eminently suitable for use across the Polar regions.

A range of transmitters and receivers specially designed for use with this system is now in production for the Ministry of Supply. Both transmitters and receivers are designed to operate in the 35 to 55 megacycle band. The transmitters have a power output of 20 kW and will be usually operated two in parallel employing a split aerial system. The equipment

is capable of high-speed operation, frequency shift keying being employed. Some of this equipment will be used to establish communication between the United Kingdom and Malta, and eventually to Cyprus and the Middle East.

Marconi's have also supplied a prototype transmitter to the Admiralty for experimental work in ionospheric scatter propagation. This is a modified television transmitter with a power rating of 30 to 35 kW and is sited at Gibraltar, the signals being beamed over the Bay of Biscay for scattering over Britain. In the light of present knowledge, however, ionospheric scatter propagation is not suitable for television as this requires a band width of at least 3 megacycles. Tropospheric scatter (which uses much higher frequencies of shorter range) offers possibilities in this direction, but much experimental work has yet to be done before the position can be assessd with certainty.

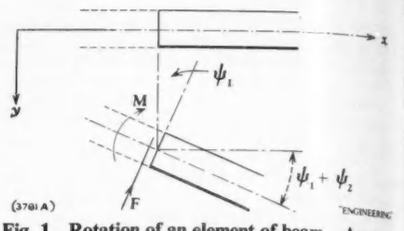


Fig. 1 Rotation of an element of beam. Account is taken of the shear forces acting at a cross-section.

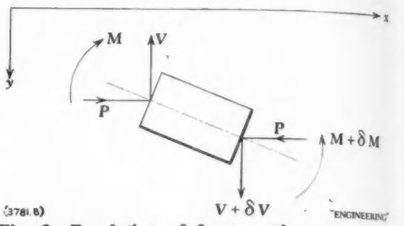


Fig. 2 Resolution of forces acting at a cross-section into vertical and horizontal sections and a moment.

SHEAR DEFLECTION IN BEAMS

GENERAL THEORY FOR STATICAL PROBLEMS

By R. P. N. Jones, M.A., PH.D.

In the elementary theory of the deflection of beams it is customary to neglect shear deflection on the grounds that it is small for beams of normal proportions (i.e., those having a length equal to several times the depth of the beam) whilst for short beams the fundamental assumptions of the elementary theory are untenable, and solutions must be sought using the theory of elasticity. The neglect of shear deflection on these grounds is probably justified for beams of rectangular cross-section, but for I-section beams, which have greater shear flexibilty, the shear deflection may be important in beams of moderate length/depth ratio. Moreover, exact solutions by the theory of elasticity are available only for a few special problems of beams of simple cross-section, and for this reason the engineer must usually rely on the elementary bending theory, even in cases where it is of doubtful accuracy. In such cases an improvement in accuracy may be obtained by the inclusion of shear deflection.

Timoshenko[1] has derived a shear correction to the elementary theory of vibration of beams, and has shown that the corrected theory is considerably more accurate for vibrations of short wave-length. The same author[2] has also discussed the effect of shear deflection in a few particular statical problems of the deflection and stability of beams, but a corrected theory applicable to statical problems in general has apparently not been published. A brief general theory is given below.

Referring to Fig. 1, let ψ_1 be the rotation at a cross-section of a beam. According to elementary theory, the bending moment M is given by the equation

$$M = - EI \frac{d\psi_1}{dx} \quad . \quad . \quad (1)$$

where EI is the flexural rigidity, and the angle ψ_1 is assumed to be small. Also, let $\psi_1 + \psi_2$ be the total slope of the neutral line. Then ψ_2 is equal to the shear strain at the neutral axis, and is given by

$$\psi_2 = \lambda \frac{F}{AG} \quad . \quad . \quad . \quad (2)$$

where F is the shear force, A the sectional area, G the modulus of rigidity, and λ is a constant depending on the shape of the cross-section. Using the notation

$$\psi_1 = \frac{dy_1}{dx}, \quad \psi_2 = \frac{dy_2}{dx} \quad . \quad . \quad (3)$$

equations (1) and (2) may be written in the forms

$$M = - EI \frac{d^2y_1}{dx^2} \quad . \quad . \quad (4)$$

$$F = \frac{AG}{\lambda} \frac{dy_2}{dx} \quad . \quad . \quad (5)$$

in which y_1 and y_2 represent the deflection components due to bending and shear, respectively.

In statically determinate problems, where the distribution of bending moment and shear force are known, the deflection components are obtained by straightforward integration of equations (4) and (5), with the insertion of appropriate end, or continuity, conditions. From equation (4) it is seen that both y_1 and $\frac{dy_1}{dx}$ must be continuous, since a discontinuity in $\frac{dy_1}{dx}$ would correspond to an infinite bending moment. From equation (5), y_2 is also continuous, but any discontinuity in the shear force produces a discontinuity in $\frac{dy_2}{dx}$. By use of equations (4) and (5) the common types of end condition may be expressed in the following forms:—

Simply supported:—

$$y_1 + y_2 = 0, \quad \frac{d^2y_1}{dx^2} = 0 \quad . \quad . \quad (6)$$

Clamped:—

$$y_1 + y_2 = 0, \quad \frac{dy_1}{dx} = 0 \quad . \quad (7)$$

Free:—

$$\frac{dy_2}{dx} = 0, \quad \frac{d^2y_1}{dx^2} = 0 \quad . \quad (8)$$

In problems where there is axial loading, or lateral elastic support M and F are functions of the deflections, and it is necessary to derive equations giving y_1 and y_2 explicitly. The most general case is that of a beam on an elastic foundation of modulus k, subjected to an end thrust P and transverse loading of intensity $p(x)$ per unit length. The forces on any section of the beam may be resolved into components P and V acting at the neutral axis and parallel to the x and y axes respectively, together with a bending moment M, as shown in Fig. 2. The equations of equilibrium of an element are

$$\frac{dM}{dx} - V - P(\psi_1 + \psi_2) = 0 \quad . \quad (9)$$

$$\frac{dV}{dx} - k(y_1 + y_2) + p(x) = 0 \quad . \quad (10)$$

which are obtained by considering moments and transverse forces respectively. The resultant shear force on a section of the beam is given by

$$F = V \cos \psi_1 + P \sin \psi_1 \simeq V + P\psi_1 \quad . \quad (11)$$

since the angle ψ_1 is small. Eliminating V from equations (9) and (10) by means of (11), and substituting from (3), (4), and (5), the two equations of equilibrium are obtained in the forms

$$EI \frac{d^2y_1}{dx^2} + \left(P + \frac{AG}{\lambda}\right) y_2 = 0 \quad . \quad (12)$$

$$P \frac{d^2y_1}{dx^2} - \frac{AG}{\lambda} \frac{d^2y_2}{dx^2} + k(y_1 + y_2) = p(x) \quad . \quad . \quad (13)$$

By eliminating y_2 from equation (13) by means of (12), an equation for y_1 is obtained as follows

$$EI \frac{d^4y_1}{dx^4} + \left\{P(1 + \alpha) - \frac{k EI \lambda}{AG}\right\} \frac{d^2y_1}{dx^2} + k(1 + \alpha) y_1 = (1 + \alpha) p(x) \quad . \quad . \quad (14)$$

where $\alpha = P\lambda/AG$. The deflection components y_1 and y_2 may be most conveniently determined from equations (14) and (12). The general solution of these equations contains four disposable constants, which may be determined from the conditions at the two ends of the beam.

An important application of the theory of beams on an elastic foundation occurs in problems of cylindrical shells under axially symmetric loading, where a longitudinal element of the shell may be regarded as such a beam. When the thickness of the shell is small in comparison with its diameter, the elementary bending theory, neglecting shear deflection, is adequate. For thicker shells, a more accurate solution may be obtained by using the theory given in this article.

REFERENCES

[1] Timoshenko, S. P., *Phil. Mag.* vol. 41, page 744, (1921).

[2] Timoshenko, S. P., *Strength of Materials*, 2nd edition (1940), published by D. Van Nostrand and Co. Inc.; Part I, page 170, Part II, page 209.

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PROCESS-CONTROL EQUIPMENT

By an agreement recently concluded between Elliott Brothers (London), Limited, Elstree-way, Borehamwood, Hertfordshire, and the Swartwout Company of Cleveland, Ohio, U.S.A., the equipment forming the "Autronic" control system is to be made in this country.

The Autronic system as developed is electronic in operation but utilises the usual air-operated regulating valves employed in process work. The complete system comprises the primary element transmitter, which feeds the recorder (or indicator) and the controller; the latter can be either manual or automatic. The last element in the chain is the power relay which receives the correcting signal from the controller and operates the valve pneumatically. Since only electric cables are employed between the plant and the control desk, there is considerable choice in the siting of the latter, making for great flexibility. Plug-in units are used throughout. Such variables as temperature, pressure, flow and liquid level can be transmitted and controlled.

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MEASURING FLOW IN PIPELINES BY AN AEROFOIL

The address of the Aerofoil Flow Metering Company Limited, referred to in the article of the above title on page 331 of our issue of September 14, was given incorrectly. It is Cross Keys House, 56, Moorgate, London, E.C.2.

FATIGUE, CASTING AND CORROSION OF SOME NON-FERROUS ALLOYS

The 48th annual autumn meeting of the Institute of Metals was held in Germany from Monday, September 17, to Tuesday, September 25, by invitation of the Deutsche Gesellschaft für Metallkunde. The meeting opened on the morning of the first day in the Liederhalle, Schloss-strasse, Stuttgart, when the chair was occupied by Professor Max Hansen, President of the host society.

Professor Hansen announced that the Heyn Medal of his Gesellschaft, for 1956, *had been awarded to Professor G. V. Raynor, who occupies the Chair of Physical Metallurgy in the University of Birmingham, for his work on the physical structure of alloys. After the official welcome, the meeting was adjourned and the delegates proceeded to the respective meeting halls for the technical sessions of the Institute of Metals and the Deutsche Gesellschaft für Metallkunde.*

ALUMINIUM FATIGUE

A discussion on the theme: "Fatigue of Aluminium and its Alloys" was held at the Institute of Metals technical session. It was based on four papers, the first being by Mr. P. J. E. Forsyth and Mr. C. A. Stubbington on "The Slip-Band Extrusion Effect Observed in Some Aluminium Alloys Subjected to Cyclic Stress," and the second by Dr. N. Thompson, Dr. C. K. Coogan and Dr. J. G. Rider on "Experiments on Aluminium Crystals Subjected to Slowly Alternating Stresses." The third paper was by Mr. J. J. Sebisty and Mr. J. O. Edwards and dealt with "Some Metallographic Observations on the Fatigue Failure of Bare and Clad Aluminium-Copper-Magnesium Alloy Sheet," and the fourth by Dr. T. Broom, Mr. J. H. Molineux and Mr. V. N. Whittaker on "Structural Changes during Fatigue of Some Aluminium Alloys."

The papers were presented by Professor H. Ford, acting as *rapporteur*.

Mr. P. J. E. Forsyth and Mr. C. A. Stubbington, who are on the staff of the Royal Aircraft Establishment, Farnborough, Hampshire, noted in their paper that the extrusion of crystalline material from slip bands had been observed during the final stages of the fatiguing of a number of solution-treated materials. Thus, solution-treated aluminium 4 per cent. copper alloy, when subjected to fatigue stresses, failed by cracking along certain sharply-defined planes, usually operative slip planes. The extruded material was in the form of ribbon, the thickness of which was estimated at less than $0{\cdot}1\,\mu$. The cracks generally exhibited what appeared to be surface debris distributed along their length, and a study of the nature and occurrence of this debris formed the subject of the present paper.

The occurrence of the cracks seemed to be coincident with the formation and extrusion of metallic ribbon and the phenomenon had been named slip-band extrusion. It was concluded from the occasional absence of slip-band extrusion from some cracks, that the effect was not itself a necessary part of the fatigue-cracking process, but was only a by-product of the type of brittle fracture that characterised these unstable alloys. Its importance lay in the fact that it provided a clue to the nature of the change that occurred on certain planes under the action of fatigue stresses.

CRYSTAL RESISTANCE

The second paper, by Drs. Thompson, Coogan and Rider, dealt with work carried out in the H. H. Wills Physical Laboratory, University of Bristol, and described apparatus used to investigate the effects of slowly alternating tension and compression on single crystals of pure aluminium. The strains involved were all small, namely, in the range 10^{-6} to 10^{-3}. The authors stated that their results dealt with the shape of the hysteresis loop; with the nature of the creep observed when the regular alternations of stress were interrupted; with the effects of this creep on the subsequent shape of the hysteresis loop; and with the interrelation between the creep rate and the rate of work-hardening.

The behaviour of the specimens when in the cyclic state had been found to be symmetrical with regard to tension and compression. For example, although almost all the creep experiments had been carried out in tension, a few observations had been made which indicated that essentially similar results would have been found in compression.

Many data had been accumulated bearing on the question of how the hysteresis loop varied during cyclic stressing. The normal behaviour under the experimental conditions in force was for the loop width to decrease continuously, both for a new specimen and for a new series on an old specimen following an increase in stress-amplitude.

There appeared to be no simple functional relationship between creep strain and time, over the whole range of time used in a creep test, but it had been found that, in all cases, a graph of creep strain plotted against the logarithm of the time was straight over an appreciable period of time.

A dislocation model of a metal crystal was proposed, the behaviour of which would appear to be—qualitatively at least—in accord with that experimentally observed.

The authors of the third paper, Mr. J. J. Sebisty and Mr. J. O. Edwards, of the Division of Physical Metallurgy, Mines Branch, Department of Mines and Technical Surveys, Ottawa, Ontario, Canada, had determined by examination of appropriate metallographic sections, the distribution of fatigue cracks in clad and bare aluminium-copper-magnesium alloy sheet specimens of various thicknesses. They stated that the specimens had been stressed in fully reversed plane bending at from 9·82 tons to 22·32 tons per sq. in., for various numbers of cycles up to and including fracture.

It had been found that the form and extent of crack damage in the clad material was influenced by the thickness of the specimen, the stress, and the number of cycles. In some instances, the crack formations were so characteristic that a reasonable estimate of the fatigue history of a specimen could be made by microscopic examination. With the bare material, however, fatigue damage had been found to be highly localised, since the first cracks to appear tended to be preferentially propagated to failure without the formation of additional cracks. In this case microscopic examination was of little value in assessing the fatigue history.

Other phenomena associated with fatigue failure had been investigated, but these had not been found to give so complete a picture of the progress of fatigue as did metallographic study.

OVER-AGEING

In the fourth paper, possible structural changes occurring during the fatigue of a number of representative aluminium alloys were considered with reference to their likely effects on fatigue life. The authors, Dr. T. Broom, Mr. J. H. Molineux and Mr. V. N. Whittaker, described work carried out in the Department of Industrial Metallurgy, University of Birmingham, and stated that a comparison of fatigue tests carried out at room temperature and at liquid-air temperature provided direct evidence for the supposition that the disappointingly poor room-temperature fatigue properties of the high-strength aluminium alloy D.T.D. 683 were due to over-ageing during the test. By similar tests, and by analogy with other alloys, the relatively good fatigue properties of the medium-strength aluminium - 7 per cent. magnesium alloy had been found to be associated with work-hardening and strain-ageing.

It was concluded that alloys of good static and fatigue strength must possess a metallurgical structure in which a stable dispersion was combined with a matrix containing sufficient solute atoms of a suitable kind to confer strain-ageing properties.

Much of the ensuing discussion was academic in character but during its course several questions of a practical nature were debated.

The first speaker, Dr. H. Sutton, observed that fatigue occurred both in metallic and in non-metallic materials and he sometimes wondered whether metallurgists paid enough attention to fatigue questions in spheres other than their own. There were fatigue problems connected with the metals used in transport equipment and in aircraft equipment, in which a leading requisite was strength combined with low weight. In the early days of aviation, aircraft engines had to be examined at very frequent intervals, but the modern engines were expected to last for thousands of hours of flying time without needing attention or inquiry into their "health and well being."

In their paper on the extrusion in "ribbon form" of alloys subjected to cyclic stresses, Messrs. Forsyth and Stubbington had stated that this extrusion occurred during the final stages of fatiguing and that it appeared suddenly. He would like to know at what order of stress or at what stage of the S/N curve this phenomenon was likely to be expected.

The next speaker, Dr. T. Broom, said that the real question to ask Messrs. Forsyth and Stubbington was how far this exudation or extrusion occurred in fully-hardened material.

LABORATORY VERSUS PRACTICE

Dr. W. M. Doyle, looking at the questions under discussion from a practical point of view, said that Dr. Broom and Messrs. Molineux and Whittaker had referred to their tests as being on a number of representative aluminium alloys. Their D.T.D. 683 alloy contained 0·12 per cent. of chromium and 0·42 per cent. of manganese, and consequently was not representative of this material. The presence of such relatively large amounts of manganese and other elements would produce segregation and this alloy was not typical of a commercial material.

Mr. P. J. E. Forsyth, in reply to Dr. Sutton, said that the extrusion effect and the crevice left as a result of this came very rapidly and fairly early during the final stages of fatiguing. They had found this extrusion phenomenon to occur in metals other than aluminium, but had not yet witnsessed it in ferrous alloys. They had observed it to occur, for example, in Monel metal at a temperature of 300 deg. C., as a result of fatigue.

Dr. R. T. Parker, another speaker who emphasised the practical aspect, said that it should be remembered that, in industry, materials were cast in far larger pieces than those studied in laboratories. The diameters of these might be 16 or 20 in.; moreover, the effect of "directionability" should be remembered in connection with fatigue experiments.

Dr. Broom, in further replies, said that investigators in laboratories depended on industry for the alloys which they worked upon and tested. With regard to "directionality" they had found that, in many cases, the fatigue properties in the transverse direction were superior to those in the longitudinal.

In a final reply, Mr. Forsyth said that questions had been asked as to whether the crack or void left by the extruded material could act as a "stress concentrator." This was a difficult matter to answer but he very much doubted whether these very small crevices would act in this way. He felt that the structural condition of the material was more important than the crack.

SEMI-CONTINUOUS CASTING OF BRONZE

The first paper of the second session, on the Tuesday afternoon, described "Experiments on the Semi-Continuous Casting of Bronze," and was by Dr. E. C. Ellwood, Dr. J. C. Prytherch and Mr. E. F. Phelps, of the Tin Research

Institute, Greenford, Middlesex. The authors stated that the aim of their investigation had been to develop a simple method for the semi-continuous casting of the common copper-base alloys containing tin, and work had been restricted to the casting of rods and tubes of a maximum diameter of 1⅝ in.

In the apparatus finally adopted, a tundish which was integral with the die was heated by a gas-fired injector furnace and was replenished from time to time during casting from a lip-axis-tilting high-frequency induction furnace. The rate of entry of the metal into the die was governed entirely by the rate of withdrawal of the solid rod from beneath. No control of pouring had to be exercised by the operator other than to fill the tundish as required. Unlubricated graphite dies were used. A maximum rate of extraction of about 12 in. per minute apparently could not be exceeded without fracturing the rods. Fracture occurred when the friction between the rod and the die exceeded the tensile strength of the rod in the hot-start range.

The factors which affected friction were the nature of the graphite and the surface of the rod. Dies of soft electro-graphite of small grain had proved best. Oxide films on the metal surface were an important factor in inducing fracture. Alloying elements which led to the formation of refractory oxides reduced the speed at which fracture occurred and, when present in sufficient quantity, prevented casting altogether. Alloying elements, the oxides of which were easily reduced by carbon at the operating temperature, were not detrimental.

Bronzes cast by the above method had coarse macrostructures, but the microconstituents were fine and well dispersed. The mechanical properties were excellent. Rods and tubes (the latter cast with the aid of a tapered mandrel) had good surfaces, and were free from all major internal and external defects.

TAPERED DIES

Mr. R. E. Berry, who opened the discussion, said that very few papers dealing with continuous or semi-continuous casting had been published by the Institute, and until the present time none had given a detailed account of the process. The authors had overcome all the difficulties which seemed to lie in wait for workers on continuous casting and had given all the necessary details for constructing and operating similar units. They claimed that the machine was relatively simple and inexpensive and that it produced a saleable product of high quality.

The authors might have been a little more specific when they mentioned the taper in the lower part of the bore of the die. A tapered die added greatly to the cost of machining, and the determination of the correct taper for every size of rod and tube would seem to be an expensive undertaking.

"Tin sweat" rings appeared to cause difficulties in the case of some alloys. The authors, however, were being very hopeful when they suggested that tin sweat might be prevented by tapering the die to fit closely the cooling and shrinking rod. The forces which caused tin bronze to sweat would seem to be too great to be suppressed by a closely-fitting die and it might be anticipated that the remedy would only give rise to more sticking.

The authors had produced sufficient evidence to show that the casting of tubes could be done satisfactorily. From their results it would appear, however, that variations in temperature had an appreciable effect on the dimensions of the tubes a variation of 1 deg. C. causing approximately 0·001 in. variation in the bore.

Most of the alloys with which the authors had experimented were bearing bronzes. Traditionally, these alloys were chill cast in metal moulds. In an observed test, a ⅞ in. diameter by 2 ft. 6 in. long solid "stick" cast in an ordinary chill mould took 6 to 7 seconds to pour and was completely solid in a further 7 to 10 seconds. In a total of 30 seconds from the start it was quite "black." The same size of rod cast by the authors' process took 2 to 2½ minutes to emerge from the die. In the early stages of solidification, therefore, the chill cast material cooled much more rapidly than that made by the continuous process. This might account for some of the increased ductility of the continuously-cast bronze.

Essentially, the new process produced long lengths of one size of rod or tube and when large orders for one size had to be fulfilled its successful application, by the bearing-bronze manufacturer, would offer to the customer real advantages in many respects. For small orders of many different sizes, however, which were a feature of this trade, the process would be uneconomic both as regards operating costs and die costs

The only other speaker, Mr. H. Hilbrans, asked the authors if they had observed tin sweat on the insides of their tube.

In answer to the discussion, Dr. Ellwood said that they had obtained tin sweat on the inside of thick tubes, but not of thin tubes.

In regard to suggested applications for the products it would be possible to make by the new process, much of their work so far had been done on a laboratory scale, and there was much more to be done before the process could be carried out on a large production scale.

At this stage of the proceedings a film entitled "A Descriptive Study of Consumable-Electrode Arcs: the Pressure Dependence of their Burn-off Rate" was exhibited by Mr. A. H. Roberson, chief of the branch of process metallurgy of the United States Bureau of Mines.

ATMOSPHERIC AND STRESS-CORROSION OF ALUMINIUM ALLOYS

The last two papers considered at the meeting were discussed jointly. Both dealt with certain aspects of the corrosion of aluminium alloys.

The first paper was entitled "Atmospheric Corrosion of Aluminium Alloys in a Large Chemical Factory and their Protection by Painting." It was by Mr. W. D. Clark of Imperial Chemical Industries, Limited, Billingham Division, Billingham, County Durham.

The author stated that a total of 1,100 specimens of five aluminium alloys in different conditions of heat-treatment and a few mild-steel specimens had been exposed on four sites in a large chemical factory for four years, and observations made on their rate of deterioration. The relative merits of 18 paint systems used on the aluminium alloys had been examined.

An alloy containing 4 per cent. of copper behaved much the worst. The aluminium-magnesium, aluminium-magnesium-silicon and aluminium-manganese alloys and 99·5 per cent. aluminium showed so little difference in corrosion-resistance that this did not appear to be an important factor in choosing between these alloys for the environments concerned. An estimated life of 7 years for bare roofing sheet under the most unfavourable conditions appeared probable as against two years for bare galvanised mild steel.

Aluminium was much superior to steel as a base for paint, and, in areas where steel required painting annually, if not more often, painted aluminium alloys showed little deterioration after four years. While zinc chromate in linseed oil was preferred as a primer, the cover coat was relatively unimportant and might be selected on a basis of cost and aesthetic appeal.

Contact tests between various materials used as washers and the upper surface of bare aluminium specimens showed only brass to be strongly detrimental. Galvanised mild steel caused the least trouble of the materials tested, but several other materials were little worse. The galvanised nut, bolt, and washer, however, were very heavily attacked and consideration should be given to the use of more resistant materials for securing roof sheets. Aluminium-alloy bolts, chromised mild steel, or mild-steel protected with a thick coat of plasticised polyvynyl chloride deserved consideration.

The second paper dealt with "The Stress-Corrosion of Certain Aluminium Alloys" and was by Dr. H. K. Farmery and Dr. U. R. Evans, of the University of Cambridge. The authors said that the removal of the grey-brown film commonly present on rolled aluminium-7 per cent. magnesium alloy by treatment in 20 per cent. aluminium chloride solution, or of the transparent γ-alumina film present on aluminium-4 per cent. copper alloy, greatly reduced the stress-corrosion life in sodium chloride. The lives dropped from several days to a few minutes. Presumably, the natural films acted as inefficient cathodes.

Sodium chloride solutions containing sodium bicarbonate produced cracking far more easily than chloride solutions free from bicarbonate. Moreover, the chloride of magnesium, calcium, or ammonium gave somewhat shorter lives than sodium or potassium chloride.

It appeared that differential stress cells had to be borne in mind by designers. Particularly in the neighbourhood of welds when covered by a film of electrolyte, the existence of a large area relatively free from stress and a small area carrying internal stresses of a tensional character, might constitute a dangerous combination, if protective coatings were not suitably maintained.

INDUSTRIAL CORROSION

The discussion was opened by Mr. E. A. G. Liddiard, who observed that few persons in Europe and the United States had any idea of the difficulties faced in Great Britain by metallurgists as the result of corrosion. For example, whereas on exposure at Billingham an alloy of the H10 magnesium-silicide type sustained a loss in thickness of 0·004 in. in four years, in New York, according to figures issued by the American Society for Testing Materials, the loss in thickness was 0·002 in. in *twenty* years. Similarly, an alloy of the H15, Duralumin type, lost 0·015 in. at Billingham in four years and 0·0012 in. at New York in 20 years.

It should be remembered, however, that the corrosion rate of aluminium decreased with time. Painting, therefore, was not necessary, especially if the aluminium used were thick enough.

Dr. H. Sutton said that trouble had been encountered in regard to the stress corrosion of rivets. Material at, and beneath, joints was often the seat of corrosion.

In the course of his reply Mr. Clark agreed with Mr. Liddiard that the indiscriminate use of paint was inadvisable. He had, however, experienced trouble on the underside of a roofing sheet, due to condensation and other influences. In some cases roofing sheets had been holed from the underside and because this type of corrosion was very local it had to be watched carefully.

AUTUMN LECTURE

The last technical session of the meeting was held on the evening of Thursday, September 20, when Professor Werner Köster of the Max Planck-Institut für Metallforschung, Stuttgart, delivered the annual Autumn Lecture of the Institute, on "Some Metallurgical Advances: How and Why They Occurred." In the course of this he referred to the introduction of the age-hardening of aluminium alloys and to the production of stainless steels as successful exploitations of chance observations or accidental discoveries. On the other hand, the important series of permanent-magnet alloys and many other materials and processes now available to the engineer were the result of patient and detailed research work. Summing up, he said that if research were to yield returns it must not be burdened by requests for results. There should be no demand for direct monetary returns. Research would produce its fruits at the appointed time and should therefore be left alone and given a free hand in the arrangement of the programme of work.

Between the technical sessions of the meeting, and on the Friday, visits were paid to engineering works in the Stuttgart area; over the week-end, the members left for Frankfurt-am-Main, and on the following two days, Monday and Tuesday, September 24 and 25, visits were made to works at Hanau, Mannheim and Frankfurt.

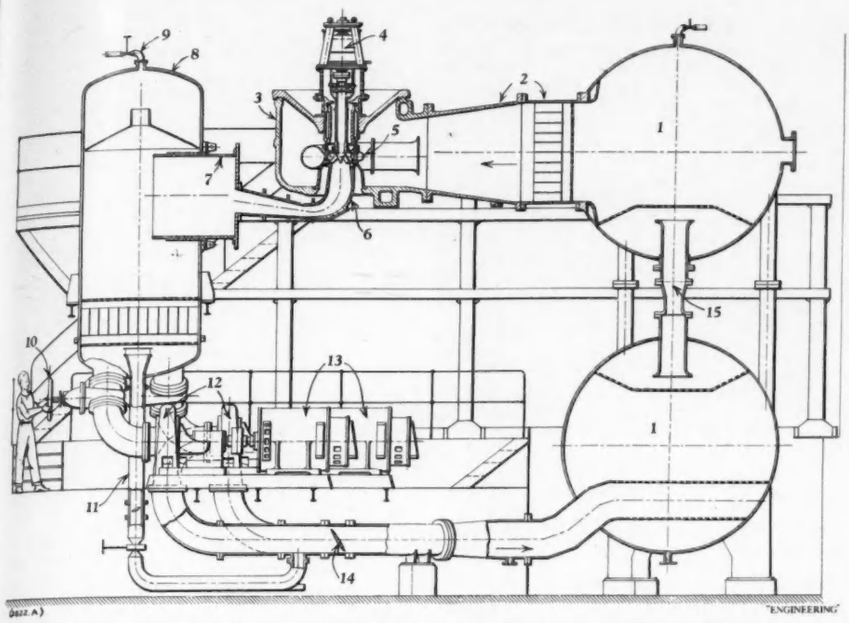


Fig. 1 The closed-circuit plant recently installed by Escher Wyss gives heads up to about 100 metres for testing models of water turbines. It can also be used for testing centrifugal pumps.

1. Spherical pressure vessels.
2. Inlet with honeycomb equaliser.
3. Turbine mounting chamber.
4. Hydraulic brake.
5. Model turbine in position.
6. Draft tube with observation windows.
7. Adaptor for different draft tubes.
8. Tail water vessel.
9. Connections to compressed air network.
10. Changeover valve for pump operation.
11. By-pass pipe.
12. Centrifugal pumps.
13. Driving motors.
14. Butterfly valve for head regulation.
15. Reversible Venturi-meter.

SWISS PLANT FOR STUDYING TURBINES AND PUMPS

STROBOSCOPIC VIEW OF CAVITATION

When making laboratory investigations on models of Francis and Kaplan turbines, the determination of cavitation phenomena in a runner is as important as the measurement of its general characteristics. As machines are developed to operate under increasing heads and to give larger outputs, the question of cavitation erosion becomes more important, and the firm of Escher Wyss Limited, Zurich, have recently installed a large testing plant for the study of this phenomenon. Another reason for the installation is the increasing amount of work now being carried out by the laboratories for outside bodies.

The new plant is designed to operate on the closed-cycle principle and has an input of 800 h.p. Previous experience on an earlier installation was used in the design, which was governed by the requirements that it should be possible to test both complete model turbines and also pumps of adequate size. Heads corresponding to those of the full-size machines were to be adopted. The maximum testing head of about 100 metres fulfills this requirement for all Kaplan and propeller turbines and for the greater number of Francis turbines, though some of the last are now being made for heads in excess of 450 metres; in these instances reduced testing heads have to be employed, as hitherto. The general layout is shown in Fig. 1.

Complete model turbines of all types, including their inlet spirals, can be installed in the turbine chamber, and very accurate measurements can be made on them. Measuring tolerances are kept small by the large braking output of 450 h.p., and the instruments can be checked exactly by simple means. The drive for the plant is provided by two separate centrifugal pumping sets which can be used in series, in parallel or separately. For heads up to 50 metres parallel operation is employed, and for part loads one pump is sufficient. Medium and high pressure turbines require the pumps to operate in series.

RANGE OF CAVITATION

The use of the closed cycle allows the cavitation coefficients to be varied within wide limits, so that for all types of turbine the stages of cavitation can range from those prior to commencement to full development. The pressure level can be changed by means of compressed air and a vacuum pump, allowing the suction head to change from −30 metres (back pressure) to +8 metres (suction head). Identical cavitation parameters can thus be obtained at widely differing heads. Possibilities of comparison are therefore great, particularly as the cavitation phenomena can be followed visually at the control desk with the aid of two observation systems; these are shown in Fig. 2. Runaway speeds, starting torques, and axial thrusts can also be measured.

Building limitations kept the upper floor surface to approximately 5 metres by 12·5 metres at a height of about 6·3 metres above the floor of the laboratory. The pumps are at floor level, and the turbine block and control desk are accessible from the upper storey. Each pump is driven by an asynchronous motor, and has a maximum delivery head of 50 metres at 985 r.p.m. with a discharge of 300 litres per second; at slightly below 40 metres head the flow is doubled. Changing over from series to parallel is carried out by means of a system of valves. Head and flow regulation are governed from the control desk through electrically-operated throttle valves.

The two head-race tanks are spherical in shape, chiefly to obtain the necessary tensile strength, and are subject to a pressure of 13 atmospheres under maximum conditions; they serve to a considerable extent as resorbers. At the full load of a turbine having a large water flow, as for example a Kaplan type, it takes 80 seconds for the water to make a complete circu t; of this period about 62 seconds are spent in the spheres and the turbine inlet. Perforated plates within the spheres ensure an even flow to the Venturi-meter and the turbine chamber. The Venturi-meter itself can be removed and reversed when the system is being used for pump trials. Provision has been made for calibrating the meter by

Fig. 3 All controls are grouped on a central desk, including the viewers for the optical systems. Behind and to the right is the turbine chamber with the hydraulic brake above it.

1. Turbine runner.
2. Plexiglass windows.
3. Mirrors.
4. Oculars on control desk.
5. Stroboscope lamp.

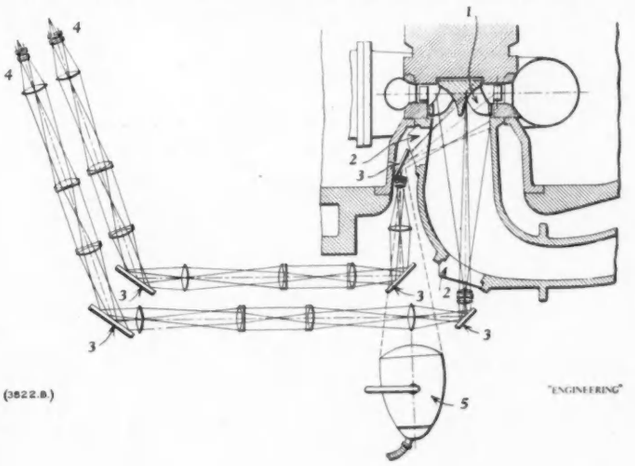


Fig. 2 Two optical systems are provided for observing different sections of the turbine.

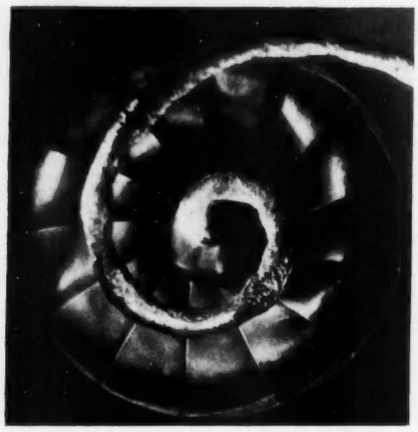


Fig. 4

Fig. 5

Figs. 4 and 5 Typical photographs, which can be taken through the two viewers under stroboscopic illumination, show the progress of cavitation.

opening the circuit shortly before the turbine chamber and passing the water diverted over a measuring weir, the latter being calibrated, before and after tests, with the aid of a measuring screen. The turbine chamber is heavily built and strongly reinforced, which reduces deformation at high pressure and also relieves the pressure on the turbine spiral, allowing the latter to be made of thin sheet; this is an important advantage for model turbines. The circuit in Fig. 1 shows a model of a 60,000 h.p. Francis turbine fitted in place.

The whole turbine output, and also the mechanical losses of the bearings, is transmitted to the hydraulic brake, as the turbine shaft is doubly supported in a so-called " frictionless " bearing system. The hollow shaft of this system makes only oscillating movements, and is supported in the adjustable ring of the guide wheel. The associated ball bearings are protected by labyrinths and a mercury gland from the operating water, whereby the friction torque of the hinged part can be kept exceptionally low. The water for the brake is supplied by a centrifugal pump driven by a synchronous motor. Regulation of the brake output is from the control desk by an electric motor and allows a maximum value of 450 h.p. to be reached. Runaway speeds can be measured by releasing the rim of the special coupling, and the starting torque is determined by blocking the brake with a locking pin in the oscillating section. Various draft tubes can be installed as required.

The tailwater vessel is only partly filled with water, and the upper air chamber is connected through remote-control valves to the vacuum pump and to the compressed air supply. It is this arrangement that allows the cavitation parameters to be varied. For constant testing conditions, float regulation is provided in the tail water vessel. The float acts through a small modified water turbine governor on the opening of a discharge nozzle which is fitted before the butterfly valve of the first pump. The fresh water to the tailwater vessel is supplied by a gear pump, giving a practically constant delivery and, therefore, a constant cooling effect. The fresh water is filtered before being introduced to the plant.

CENTRAL CONTROL

Special care was paid to the accuracy of the measuring devices as alteration in the shape of a model turbine often only leads to a very small difference in efficiency; consequently all measuring tolerances were kept very low. All the devices and supervisory instruments are mounted centrally so that they can be operated and checked by a single engineer. The desk is shown in Fig. 3. Switches for the auxiliary motors are on the left-hand side, together with the ammeter for the main motors and the position indicators of the three butterfly valves. In the centre section are the torque instruments, the electronic speed measuring devices and the remote-reading thermometers. On the right-hand side is the stroboscope and the eyepieces of the optical system for visual observation of the cavitation. On the same side are controls for the valves regulating the pressure in the tail water vessel. Load and brake regulators are located in the lower part. Hydraulic pressure is measured by its action through an intermediate oil container on a finely machined piston which is connected to the balance scale at the control desk. A mercury pressure gauge is available for quick calibration, for example when measuring a head of 50 m. the calibration sensitivity is approximately 2 cm. of water.

The torque measuring device has an arm, connected to the swinging part of the water brake, acting through levers and knife-edge bearings on a piston as a pressure transmitter, so that an oil pressure proportional to the turbine torque is set up in the corresponding cylinder on the control desk. The transmitted force is determined by calibrated weights which can be added or removed by an electric motor so that the load on the brake can be quickly changed from the control desk during tests. This device is very sensitive and differences between load applied and turbine torque are detectable at $\pm$ 0·04 kg.-m. In the full-load range of the Francis turbine shown in Fig. 1 this represents 0·03 per cent. The axial thrust of the turbine is transmitted to four elongating bolts in the turbine block and is determined by measuring the change of length.

To observe, cavitation from the control desk, two special optical devices (Fig. 2), designed in co-operation with Messrs. Wild of Heerbrugg, are used. These permit observation of the runner through two differently situated windows in the draft tube, a very strong stroboscopic lamp being employed which enables photographs to be taken at the control desk. Examples of such photographs are given in Figs. 4 and 5.

The testing plant can also be used for investigations on pumps; in this case an electric motor, of which the output can be measured, replaces the brake, and the variation in delivery head is brought about by the butterfly valves. Cavitation parameters can be adjusted as in the case of the turbine trials by changing the pressure in the tailwater vessel.

I.E.E. WIRING REGULATIONS EXPLAINED

Some Difficulties of Interpretation

The thirteenth edition of the Regulations for the Electrical Equipment of Buildings was issued by the Institution of Electrical Engineers just over a year ago. It has now been followed by a first list of interpretations, which have been made as the result of enquiries. In preparing this document no attempt has been made to comment on particular installations or types of equipment and material, as this duty falls within the province of the consulting engineer or testing establishment. Nor does the Institution adjudicate on differences of opinion, which may arise between supply undertakings and consumers, as these matters are covered by statute.

In reply to a criticism that the application of Regulation 108 to circuit-breakers was not clear it is laid down that, subject to the exemptions given in that regulation and Regulation 316 (B) a circuit-breaker designed for instantaneous operation must be set to operate at a current not exceeding twice the rating of the cable protected. With similar exemptions a circuit-breaker operating only with time delay (or having an inverse-time characteristic) must be so arranged that the normal continuous current, for currents appreciably above which the circuit-breaker operates within a stated time, does not exceed the rating of the cable. A circuit-breaker having both instantaneous and time-delay settings must be so arranged that at least one of the settings complies with the foregoing.

The definition of " incombustible " is amplified by the information that the plastered surface of lath and plaster or plaster over plaster board used alone, where continuous and free from cracks is incombustible, unless it is paper-covered. Hardboard is not incombustible.

At a distribution board supplying a motor and its starter a fuse of greater rating than that for the full load current may be needed to allow for starting. The rating of this fuse must not, however, exceed twice the rating of the cable between the board and the starter. A cable of greater rating than the sustained current may therefore be necessary in this part of the circuit. The earthing arrangements must also be adequate in relation to the fuse rating.

Conductor identification, the switching and protection of heating appliances and the ratings of paper-insulated and varnished-cambric-insulated cables are also dealt with.

* * *

VERTICAL ELECTRICAL PUMP

As an addition to their range of centrifugal self-priming pumps, Pegson Limited, Coalville, Leicestershire, have developed a compact vertical set. It has a maximum width of 13 in. and a base diameter of 12$\frac{1}{8}$ in., so requiring very little floor space. The pump is driven from an electric motor, flange mounted above the pump casing, the impeller being mounted on an extended motor shaft. It has a capacity of 3,300 gallons per hour and is manufactured in a 2 in. size. Two models are available, one with a $\frac{3}{4}$ h.p. motor and the other with a 1 h.p. motor. The pump will work against a total head up to 33 ft. and a maximum of 23 ft. suction lift. The motors can be either totally-enclosed standard models, or specially flame-proofed.

* * *

In the text of our recent article on " Gear Cutting " (ENGINEERING, August 24, page 246, 1956) we stated that Fig. 19 showed the VS.4A fine-pitch gear-shaving machine made by W. E. Sykes, Limited, Manor Works, Staines, Middlesex; the machine illustrated was in fact the Sykes VS.8A model. In addition, although certain factored items, including three Klingelnberg machines referred to in the article, were, as we indicated, also shown on the W. E. Sykes stand at the International Machine Tool Exhibition, and were listed under their name in the catalogue, the company wish us to emphasise that the agents for these machines are the Sykes Machine Tool Company, Limited, Hythe Works, The Hythe, Staines, Middlesex.

Book Reviews

THE ATOM AND ITS NUCLEUS

An Outline of Atomic Physics. By OSWALD H. BLACKWOOD, THOMAS H. OSGOOD and ARTHUR E. RUARK. Third edition. *John Wiley and Sons, Incorporated*, 440 *Fourth-avenue, New York* 16, *N.Y., U.S.A.* (7.50 dols.); and *Chapman and Hall, Limited*, 37 *Essex-street, London, W.C.2.* (60*s.*)

With the rapid development of atomic energy in recent years there is now a wide interest in atomic (and nuclear) physics outside the select circle of nuclear physicists. Each new book on atomic physics, therefore, has to be considered from the point of view of this wider circle of potential readers. The book under review first appeared in 1933 and dealt with the material usually covered in a course of "modern" physics in the third year of a standard university course of that time.

Atomic physics is a science which, to be studied adequately, requires unusual equipment. Nowadays, pure science is intimately associated with its practical applications, and here a group of students at the Oak Ridge School of Reactor Technology are seen conducting a nuclear experiment. The results may yield an insight into nuclear principles.

A great deal has happened in the world of modern physics since 1933, and the present book bears little resemblance to the earlier editions, except in the arrangement of the chapters. Much has had to be re-written and much new material has been introduced. However, some of the material from the earlier editions which has been included has had the benefit of the evolutionary process of simplification and clarification that time and discussion can provide, and the presentation here is excellent.

In certain of the book's later chapters, where the authors are discussing the results of more recent researches, and where the theoretical background has been and, in some cases, still is, in a state of flux, the authors' difficulties in choosing one interpretation rather than another will be readily appreciated, though the treatment may be regarded in some cases as unsatisfactory.

But, although the expert may not always find his own views expressed, this is a small matter for the general reader, to whom this book is directed. It does, moreover, present its material in an interesting and readable manner. In fact, this is probably the main feature of the book—it is very readable.

Roughly half of it is devoted to standard atomic physics; chapters are included on the atomic nature of matter, the atomic nature of electricity, the nature of radiant energy, the Bohr model of the atom, X-rays, waves associated with material particles, atomic spectra and the Pauli principle, the periodic system and molecular structure.

The second half of the book contains most of the new information, and the authors have selected the material to illustrate the principles of the subject, rather than the details. The chapter on radioactivity, which includes an account of the discovery of radioactivity, the breakdown of radioactive elements, the statistical nature of radioactive decay, the natural radioactive elements, the energy of individual particles and gamma-rays, magnetic spectrographs, alpha-ray spectra, gamma-ray spectra, and beta-ray line and continuous spectra, is a very interesting and full account of the various subjects.

There are also separate chapters on elementary particles, transmutation and nuclear structure which bring the essentials of the subjects in a clear and concise manner. The chapter on the applications of nuclear physics covers a great deal of ground and includes an explanation of nuclear fission, the mode of operation of a nuclear reactor (or atomic pile), the types and uses of nuclear reactors, and the methods of production and the various applications of radioactive isotopes.

The expert will again find much to criticise in this chapter, but as an introduction to the subject the reviewer is of the opinion that the authors have maintained a good balance of their material, and that the presentation is stimulating and likely to awake, as the authors hope, "a love of physics and a respect for its achievements" in the minds of at least a proportion of their readers.

The last two chapters deal with cosmic rays and the theory of relativity respectively. Here again the authors have succeeded in presenting to their readers a thoroughly up-to-date (as at 1955) explanation of the subjects. The chapter on cosmic rays is particularly good from this point of view and gives a very comprehensive and clear account. Emphasis is laid on experiment for the most part, but a short section is included on the origin of cosmic rays.

The book concludes with a number of useful appendices and a bibliography, and each chapter ends with a list of problems and exercises to which answers are given. It is well printed and illustrated and appears to contain few errors. It is a book that can be recommended.

NEW BOOKS

Some of the books noticed here are selected for extended review in ENGINEERING.

Working Stresses for Structural Softwoods. By J. G. SUNLEY. Forest Products Research Bulletin No. 37. Published for the Department of Scientific and Industrial Research by *H.M. Stationery Office, Kingsway, London, W.C.2.* (1*s.* 3*d.*)

The safe working stresses for the two structural grades of home-grown timbers can be derived from tests on small clear specimens by a method described in this *Bulletin*. The method takes into account the natural variability in the strength of timber and includes a safety factor. Working stresses are derived for all the strength properties likely to be required in designs for nine of the most widely grown British softwoods and for three of more commonly used imported ones.

The Sampling and Analysis of Rolled Asphalt and Coated Macadam. Road Research Technical Paper No. 36. Published for the Department of Scientific and Industrial Research by *H.M. Stationery Office, Kingsway, London, W.C.2.* (3*s.*)

This Paper describes an investigation by the Road Research Laboratory into the methods currently used for the analysis of asphalts and coated Macadam. In particular, the investigation found that the methods, when properly used, gave an accurate determination of the composition of the samples, but showed that the ways in which the sample, or samples, may be collected was open to criticism. The Paper makes a number of recommendations as to the best way of deciding the number of samples required and of then obtaining them.

The Analysis of Structures. By N. J. HOFF. *John Wiley and Sons, Incorporated*, 440 *Fourth-avenue, New York* 16, *N.Y., U.S.A.* (9.50 dols.); and *Chapman and Hall, Limited*, 37 *Essex-street, London, W.C.2.* (76*s.*)

This book on structural analysis differs from the majority of texts on this subject by its arrangement. The author claims in his preface that the whole subject may be presented as a logical and unified theory based on a small number of first assumptions. The book therefore, is, divided into four sections: the principle of virtual displacements; the minimum of the total potential; the calculation of buckling loads; and the complementary energy and least-work methods. Each section begins with the statement of the fundamental principles appropriate to the section, followed by applications to design practice. The book is based on the curriculum in use for engineering students at the Polytechnic Institute, Brooklyn, U.S.A.

★ ★ ★

TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Non-Destructive Testing of Engineering Materials. A. E. CAWKELL, electronic engineers, 6-8 Victory-arcade, The Broadway, Southall, Middlesex. Two instruments for the non-destructive testing of the properties of materials, mainly of the non-homogeneous types, such as concrete, plastics, coal, ceramics and wood. The UCT model is used to measure the time of propagation of a pulse of longitudinal vibrations of ultrasonic frequency through the specimen. The second instrument, model SCT, a sonic or electro-dynamic materials tester, is used to measure the resonant frequency of a specimen by mechanically connecting it to a vibrator. The frequency is varied until resonance is reached. The SCT instrument is better suited to laboratory work, while the nature of the UCT apparatus makes it suitable for work on complete structures. Descriptive booklet.

Phosphate Metal-Finishing Process. THE PYRENE CO. LTD., METAL FINISHING DIVISION, Great West-road, Brentford, Middlesex. "Parco-Lubrizing" is a phosphate process specially formulated for treating ferrous-metal surfaces to reduce wear. It is designed to eliminate galling, scuffing, pick-up and local welding during running-in periods. Explanatory leaflet.

Automatic Bar and Chucking Machines. ALFRED HERBERT, LTD., Factored Division, P.O. Box 18, Red Lane Works, Coventry, sole British agents for "Gildemeister" automatic bar and chucking machines. Four and six-spindle bar machines, with round bar capacities from 1⅞ in. to 2¾ in. diameter; chucking capacities from 6 in. to 7¾ in.

diameter. Also chucking machines of the tool-rotating type, with turning lengths of 6 in. or 7½ in. Two illustrated brochures, with details of typical work done by the machines.

Petroleum Equipment and Services. THE COUNCIL OF BRITISH MANUFACTURERS OF PETROLEUM EQUIPMENT, 2 Princes-row, Buckingham Palace-road, London, S.W.1. Directory containing a classified list of equipment and services supplied by members of the Council. This comprises three main sections, namely, a list of members, the classified list of equipment and services, and an index to the classified list. (Price 5*s*.)

Coating Processes for Metals. THE JENOLIZING CO., LTD., 13-17 Rathbone-street, London, W.1. Technical data on the firm's accelerated zinc phosphate coating process for ferrous and zinc metals; the unaccelerated manganese phosphate coating process for ferrous metals; and the chromate oxidation coating process for aluminium and its alloys. Three folders.

Precious Metals and Pure Chemicals. JOHNSON, MATTHEY & CO. LTD., Hatton-garden, London, E.C.1. The products and services of the firm's bullion department, and industrial, jewellery, chemical, and ceramic divisions, illustrated and succinctly described in a book entitled: *An Industry within Industry*. (*The place and purpose of Johnson, Matthey*.)

Copper Valuation Calculator. METALLIC EXTRACTORS (NON-FERROUS) LTD., Fairforal Works, Marsh-lane, Water Orton, Birmingham. Metallic copper valuation chart calculator for low-grade residues containing a maximum of 20 per cent. of copper. The 10 per cent. copper valuation, and the plus or minus 1 per cent. value, are given for copper values ranging from £208 to £503 per ton.

Wood Preservatives. SOLIGNUM LIMITED, Donnington House, 30 Norfolk-street, Strand, London, W.C.2. A description of the causes and treatment of dry rot, deterioration by wood worm and termites, and other forms of attack on timber, in the interior as well as on the exterior of buildings. Descriptive booklet and wood-preservative colour card.

Earth-Loop Impedance Test Set. FOSTER TRANSFORMERS LTD., South Wimbledon, London, S.W.19. Test set for determining the earth-loop impedance of the circuit from which it is energised or of an external "dead" circuit. Technical particulars. Illustrated leaflet.

Heat-Treatment Furnaces. GIBBONS BROTHERS, LTD., P.O. Box 19, Dibdale, Dudley, Worcestershire. Continuous normalising, hardening and annealing gas-fired furnaces of the disc-hearth, walking-beam, pusher-bar and other types. Illustrated descriptive folder.

Sintered-Metal Components. MACHINE PRODUCTS LTD., Kembrey-street, Swindon, Wiltshire. Die-pressed sintered-metal components in iron, steel, bronze and brass, obtained by powder metallurgy. Their advantages, limitations and specific uses. Illustrated brochure.

Pneumatic Power Operators. JAMES GORDON & CO. LTD., Dalston-gardens, Stanmore, Middlesex. Pneumatic power operators for the remote or automatic operation of valves, dampers, and rheostats by means of compressed air. Leaflet catalogue.

Paint for Steel Structures. GOODLASS, WALL & CO. LTD., 179-185 Great Portland-street, London, W.1. Methods of preparation of steel surfaces and their protection by means of protective paints. Illustrated folder.

Chemical Plant. PETROCARBON DEVELOPMENTS LTD., 17 Stratton-street, London, W.1. Examples of plant, designed and erected for the chemical and petroleum industries in this country and in various parts of Europe. Illustrated folder.

High-Duty Light Alloys. HIGH DUTY ALLOYS LTD., Slough, Buckinghamshire. Technical data on hot-rolled aluminium-alloy plates, cold-rolled sheets and circles, and hints on their blanking, deep drawing, spinning and welding. Brochure.

PAY-AS-YOU-SEE TELEVISION

SOME TECHNICAL CONSIDERATIONS

As remarked in Weekly Survey, television organisations in the United States believe that there is a considerable following for the type of entertainment which cannot be profitably sponsored by advertising interests. That public would, it is considered, support some form of subscription service and much ingenuity, therefore, has been exercised in providing systems of this kind which shall be both technically efficient and free from abuse, either by viewers themselves or by rival interests. Among these, is the system of the International Telemeter Corporation, 2,000 Stoner-avenue, Los Angeles, California. This is dealt with in detail in a booklet, which has been submitted to the Federal Communications Commission in Washington, a body charged with the duties of authorising and regulating "pay-as-you-see" television.

In this system both picture and sound are encoded at the transmitter and decoded at the subscriber's receiver in an attachment which comprises a coin box and various electronic circuits. When a viewer, whose set is fitted with this attachment, tunes to a television channel operated by the Corporation he sees a picture, or "marquee," explaining that a "pay-as-you-see" programme is being broadcast and is informed of the nature of that programme and its price. He is also informed audibly of the price of the programme and given other information by what is known as a "barker," while the coin box displays the price of the entertainment that is being shown, or will be shown. If the viewer with the Telemeter attachment wishes to see and hear the programme he deposits the appropriate fee in the coin box. The programme picture is then automatically substituted for the marquee and the programme sound for the previous audible announcement or barker.

For the purposes just mentioned, six groups of signals are sent from the transmitter to the receiver: those transmitting coded sound and video and those transmitting the marquee and barker. In addition, a signal is sent which decodes both the picture and the sound at the receiver; while others are transmitted to set the price-wheel in the coin box and to mark the programme purchased on a record card.

AUDIO SYSTEM

The audio system employed in the Telemeter uses two channels, one of which is normal while the other consists of the lower side band produced by suppressed carrier amplitude modulation. The programme is transmitted on one channel and the barker on the other, the two being periodically interchanged. When this interchange takes place, a signal is transmitted to the receiver so that the viewer who has paid his fee will continue to receive the programme and the one who has not paid will continue to receive the barker. To eliminate spurious signals, which could be used by unauthorised persons to detect the moment of switching, the change-over is made slowly. For the same reason, the programme is transmitted on both channels, the object of this and other variations in the cycle being to frustrate "pirates" who might attempt to cheat the system by monitoring both audio channels and using the coincidence of the two programmes as a switching signal.

VIDEO SYSTEM

Limitation of the reception of the picture to viewers who have paid and the prevention of piracy also determine the video system employed. The first of these objects is achieved by modulating the programme video at the transmitter by a sub-carrier with a frequency of about 3·99 megacycles and vestigially suppressing the upper side band, so that the signal contains harmonic components within the conventional frequency limits. The result is that the video is moved from frequencies of high visibility to those of near zero visibility. Normal visibility, however, is restored by demodulation in the Telemeter.

Modulation in this way provides room for the marquee in the lower part of the channel, so that both it and the programme video can be combined in a single signal within the normal band width. This combined video signal is used to modulate the radio frequency carrier of the transmitter, the combined signal received being demodulated in the Telemeter on which payment has been made, so that only programme video is presented. On payment, too, the marquee video is moved to frequencies of near zero visibility, most of the high-energy frequency components are removed and the total energy of the marquee is kept below one half that of the programme video, so that there is no disturbance of the reconstituted programme. Where no payment has been made to the Telemeter, only the marquee is produced.

Since the subcarrier has been suppressed, it is necessary to provide a carrier of the proper frequency and phase at the receiver to demodulate the programme video. This is done by a stable phase-locked oscillator in the Telemeter, which is kept running at the proper frequency and phase by synchronising it with pulses from the transmitter. A further degree of security is obtained by modulating the programme video by one of the two outputs of the subcarrier oscillator at the transmitter. The phase that is being used is passed from the control unit of the transmitter to the receiver, so that the proper phase for demodulation can be selected.

DECODING PROCEDURE

As already mentioned, to enable the Telemeter to decode both picture and sound, a code signal is transmitted. This consists of 16 binary digits, ten of which form a number for identification, while two groups of three provide decoding instructions for sound and video, respectively. The signal is changed from programme to programme by a drum in the coin box, which sets the price of the individual programmes into the coin-demand mechanism and determines the position of the stylus which prints a mark identifying the programme on a card. It also sets the position of the code drum for the individual programme, so that the appropriate circuits receive the decoding signals.

The encoder consists of control, video and audio circuits and the generator for the coin-box signal. The control unit governs the coding of the video and audio signals, and generates the code message which is used to decode these signals at the receiver. It also controls the phase selector, which chooses the phase of the video recorder and one or other of the transmitting channels. Finally, it generates the digits of the code message. The programme and marquee video and audio signals are generated in the video and audio sections of the recorder, respectively, while the pulses which control the coin box are generated by the coin-box signal generator.

ECONOMIC CONSIDERATIONS

The makers of the Telemeter stress that, although the system demands certain additions to the transmitter, these do not add materially to its complexity. The Telemeter at the receiving end consists of an electronic circuit with 19 valves and five relays. The attachment of this unit to existing receivers has no adverse effect on their operation and Telemetering facilities can be provided within the band width at present assigned to television. It is also claimed that the quality of the Telemeter programme is better than that of sponsored programmes, owing to greater modulation of the transmitter with less average power, better signal-to-noise ratio (owing to synchronous demodulation) and better horizontal synchronisation. It is true that the circuitry is complicated, but this is principally due to operation being based on the insertion of a coin and to the necessity of providing against unauthorised usage.

SEA-WATER COOLING USED AT FLEETWOOD POWER STATION

A power station at Fleetwood in the Fylde area of the North West, Merseyside and North Wales Division of the Central Electricity Authority was recently formally opened. After several sites had been examined it was found that there was none where sufficient water could be economically obtained for direct cooling. It was therefore necessary to install towers, the site finally chosen, which covers about 50 acres, being that of a disused timber pond near the docks. Owing to the nature of the subsoil it was necessary to drive some 4,000 piles with an average length of 25 ft. on which steel-framed buildings with reinforced-concrete floors and brick cladding were erected. An external view of the present station appears in Fig. 1. Other civil engineering work included the formation of ash ponds which were constructed on an area of about 64 acres by forming bunds across the adjacent marshes. Local sand and silt were employed for this purpose, the same materials being used to raise certain low-lying portions of the site. Messrs. L. G. Mouchel and Partners, 36 Victoria-street, London, S.W.1, were consultants for this part of the work, H. S. Fairhurst and Son, Manchester, being the architects.

Coal for the station, which will have an ultimate capacity of 180 MW, is brought in by rail and is unloaded by a single side-discharge tippler on to a belt conveyor which takes it direct to three 500 ton boiler-house bunkers. This system is capable of handling 200 tons of coal per hour. Alternatively, coal can be placed on a stocking ground with a capacity of 77,000 tons.

STEAM RAISING PLANT

The present steam raising plant consists of three pulverised-fuel-fired boilers, each of which has an output of 300,000 lb. of steam per hour at a pressure of 625 lb. per sq. in. and a temperature of 865 deg. F. Two of these are of the Simon-Carves tri-drum type and the third of the Foster Wheeler single-drum pattern. Associated with them are Melesco superheaters on the first two boilers and Foster Wheeler equipment on the third, all units being of the self-draining type. The air heaters are of the Howden-Ljungstrom rotary pattern and the economisers are of Green's design. Draught is obtained from two forced-draught and two induced-draught fans on each boiler, while pulverised fuel is supplied to the furnaces by exhauster fans on Nos. 1 and 2 boilers and by primary air fans on No. 3 boiler. All these fans are electrically driven through hydraulic couplings to give variable speeds. The coal for each of Nos. 1 and 2 boilers is pulverised in three Lopulco suction-type mills and for No. 3 boiler in two Foster Wheeler pressure-type ball mills. Fig. 2 is an illustration of the boiler-house basement showing the line of eight pulverising mills.

Each boiler is automatically controlled by Bailey pneumatic equipment and the superheat is regulated by Kent apparatus. The control boards are illustrated in Fig. 3, which also shows the coal feeders.

Dust is removed from the flue gases by electrostatic precipitators and is extracted from the hoppers of the latter by Redler conveyors which deposit it in the ash sluice. The cleaned gases pass to a single 300 ft. chimney. Ash from the furnaces and the precipitator dust is conveyed by water in a low-pressure sluice to pumps which transmit it through a pipeline, 1,500 ft. long, to lagoons where settlement takes place. The overlying water is then filtered and drained away to the estuary.

COOLING WATER ARRANGEMENTS

The present generating plant consists of three English Electric sets each with an output of 30 MW. The turbines of these sets, of which one is illustrated in Fig. 4, are of the two-cylinder impulse reaction type, the high-pressure cylinder comprising 20 impulse stages arranged for single flow and the low-pressure cylinder 20 reaction stages arranged for double flow.

The steam is exhausted to twin two-pass condensers with a designed vacuum of 28·7 in. at a load of 24 MW, and a cooling-water temperature of 65 deg. F. Cooling is entirely effected by sea water which is circulated between the station and the cooling towers through reinforced-concrete culverts. One pump with a capacity of 25,000 gallons per minute is provided for each set and the water is normally drawn from the adjacent Fish Dock; or when that is impossible, due to the height of the water level in the dock, from a specially built storage reservoir.

The two cooling towers are 250 ft. high and have been designed to cool 3,000,000 gallons of water per hour through a range of 14·8 deg. F. In their construction sulphate-resisting cement was used to minimise the risk of disintegration caused by chemical reaction between sulphates in the sea water and the tri-calcium aluminate present in ordinary Portland cement. Each tower pond has a capacity of 1·15 million gallons.

FEED HEATING

Condensate is withdrawn from the condensers by two electrically driven extraction pumps for each set, both of which are capable of handling the full quant-

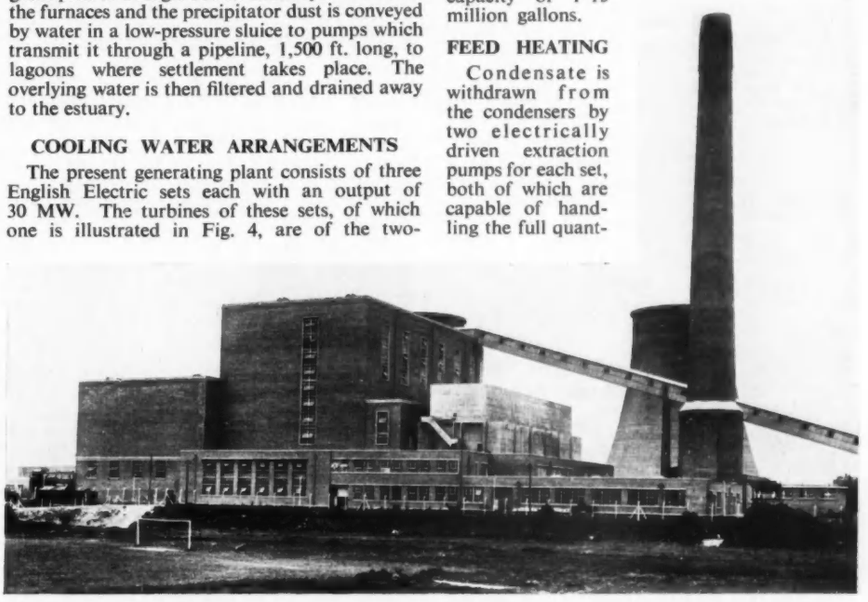


Fig. 1 Fleetwood coal-fired power station, the ultimate capacity of which will be 180 MW. Steam is at present obtained from three boilers using pulverised coal.

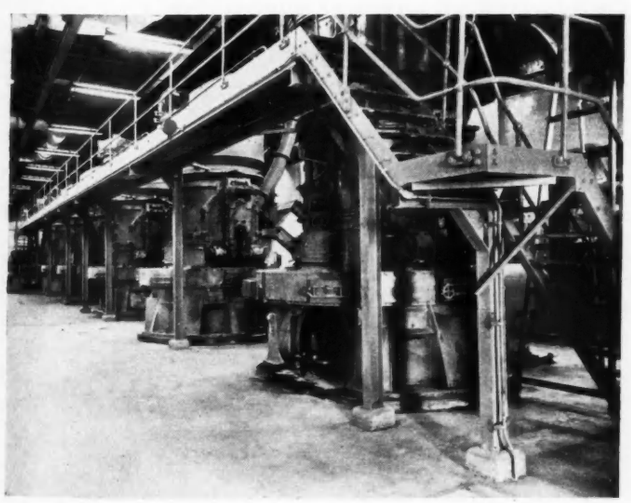


Fig. 2 The eight pulverising mills for the three boilers are located in the basement.

Fig. 3 Automatic pneumatic control equipment is used for the boilers. On the right are the coal feeders.

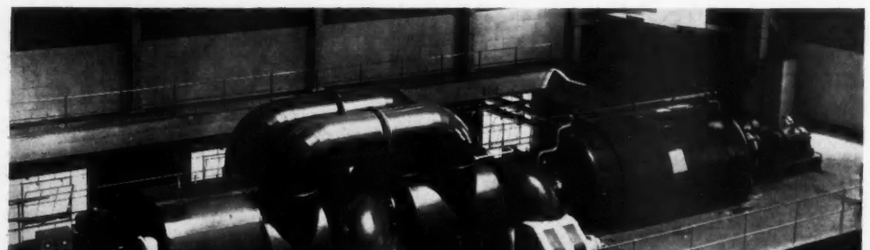


Fig. 4 One of the three 30 MW English Electric generating sets which have been installed in Fleetwood power station to date.

ity. The air extractors are of the steam jet air ejection type, there being two 100 per cent. duty units for each set as well as a quick start ejector. There are two shunt de-aerators each of which has a capacity of 65,000 lb. per hour and one of which can serve two sets. There are two low pressure and two high pressure feed water heaters for each set, while the pumping plant consists of five electrically driven pumps each with an output of 330,000 lb. per hour. There is also one stand-by steam driven pump for each set with an output of 165,000 lb. per hour. The final feed water temperature is 360 deg. F. at 30 MW.

ELECTRICAL EQUIPMENT

The alternators, which are air-cooled with direct-driven exciters, run at 3,000 r.p.m. and generate three-phase current at 11 kV. They are connected to 33 kV busbars, through 36 MVA transformers, which are equipped with tap-changing gear. The high tension sides of these transformers are controlled by switchgear of the horizontal drawout metalclad type with a rupturing capacity of 750 MVA and duplicate condenser type busbars. The fault level has been limited to 750 MVA, with four generators connected, by the use of a 12·5 per cent. on 45 MVA cast-in-concrete reactor which is connected between two sections of the four section switchboard.

As regards station auxiliary supplies each boiler/turbine unit board is supplied through 3 MVA, 11·8/3·45 kV transformers, which are directly connected to the alternators. Supplies for starting-up purposes are available from two 6 MVA, 33/3·45 kV station transformers. The necessary unit switchgear is mounted on the operating floor near the plant it controls. The switchgear supplying the high-powered auxiliaries is of the 150 MVA, 3·3 kV air-insulated truck type, while that supplying the low powered equipment is 25 MVA, 415 volt switch and contactor gear. All the motor circuits are controlled by contactor gear backed by high rupturing capacity fuses. The control and relay rooms are situated in an administration block which is connected to the turbine house by a bridge.

The Controller of the North West, Merseyside and North Wales Division is Mr. A. R. Cooper, the chief generation engineer (Construction) is Mr. C. R. Watson Smyth and the station superintendent at Fleetwood, Mr. E. B. Thorpe.

The principal contractors engaged in the construction and equipment of the station were:

M. J. Gleeson (Contractors), Ltd., Sheffield, for the civil engineering work and buildings; Edward Wood & Co. Ltd., for the structural steel work; J. Gerrard & Sons, Ltd., for the chimney; Fred Mitchell & Sons, Ltd., for the cooling towers. The coal and ash and dust-handling plant was manufactured by Simon-Carves, Ltd., Stockport, who also supplied two of the boilers and all the electrostatic precipitators. The third boiler was designed by Foster Wheeler, Ltd., 3 Ixworth-place, London, S.W.3, and manufactured by Richardsons Westgarth (Hartlepool) Ltd. All the economisers were supplied by E. Green & Son, Ltd., Wakefield, the forced and induced-draught fans by Jas. Howden & Co. (Land), Ltd., Glasgow, and the automatic boiler-control equipment by Bailey Meters and Controls, Ltd., Croydon. The superheaters on Nos. 1 and 2 boilers were manufactured by the Superheater Co. Ltd., London, S.W.1, and that on the third by Foster Wheeler Ltd.; English Electric Co. Ltd., Kingsway, London, W.C.2, were responsible for the turbo-alternators, main transformers, and 33 kV and 3·3 kV switchgear; the auxiliary transformers and the 415 volt contactor gear were manufactured by Metropolitan-Vickers Electrical Co. Ltd., Manchester 17. The main contractors for the feed-heating and condensing plant were Vickers-Armstrongs Ltd., Westminster, London, S.W.1, the pumps being supplied by Drysdale & Co. Ltd., Glasgow, W.4, and the ejectors by G. & J. Weir, Ltd., Cathcart, Glasgow, S.4.

Fig. 1 (left) Switchboard with new medium-voltage withdrawable circuit-breakers, which are made by George Ellison and Co. Ltd.

WITHDRAWABLE SWITCHGEAR FOR MEDIUM VOLTAGES

Standard Arcing Contacts Used

A new range of medium voltage withdrawable switchgear has recently been placed in production by George Ellison, Limited, Perry Bar, Birmingham 22B. This gear, which is illustrated in Fig. 1, below, has been designed to give long life, reliable service and easy maintenance. During the preliminary stages of its development it was subjected to exploratory tests in the firm's A.S.T.A. testing station.

The equipment incorporates horizontally isolated drawout circuit-breakers for voltages up to 660 volts and with carrying capacities of 400, 600, 800 and 1,200 amperes, the rupturing capacities being between 37·5 MVA or 45 MVA at 600 volts or 25 MVA and 30 MVA at 400 volts.

The fixed main contacts, and the fixed and moving arcing contacts, which are shown in Fig. 2, are identical throughout the range, although the number of arcing contacts varies. This has the important advantage of reducing the variety of spares to a minimum. The contact mechanism is protected by a spring-assisted oil-filled shock absorber. When the oil tank is full, a single operation of the breaker is normally sufficient to ensure that the shock absorber is full. The spring protects the contact mechanism when the breaker is operated with the tank lowered for maintenance purposes. The main and arcing contacts are individually reversible and a complete moving contact-assembly can be reversed by removing and refixing only two set screws.

PROTECTIVE DEVICES

Complete protection of plant and equipment is provided by series-wound solenoid-operated overcurrent and undervoltage releases. The overcurrent releases are adjustable between 90 and 200 per cent. of the full-load current and are fitted with triple-action dashpot lugs which allow transient high overcurrents to pass. They, however, release on sustained overcurrents, according to their setting. The undervoltage coil acts directly on the trip mechanism. A shunt trip coil may be fitted in place of the undervoltage coil or of one of the overcurrent coils.

The isolation of a circuit-breaker from the busbar chamber is a simple and safe operation. The breaker cannot be closed nor the cover removed from the tank until full isolation has been completed. Auxiliary switches which are contained in moulded cases are housed in the tank below the oil.

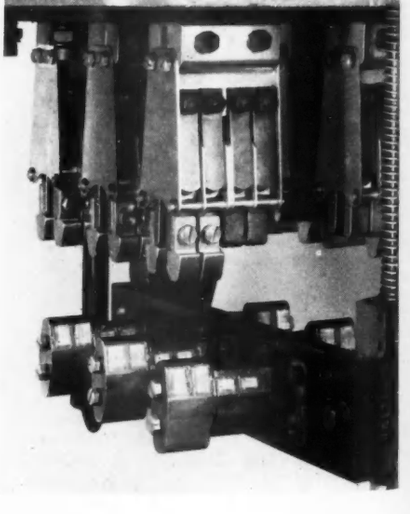
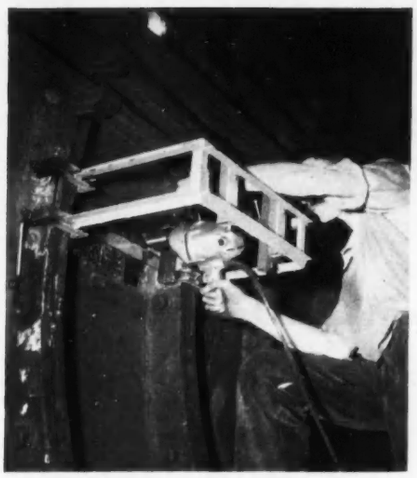


Fig. 2 (right) The main and arcing contacts which are individually reversible. The whole contact assembly can also be reversed by removing two set screws.

CAST-IRON TUNNEL LININGS

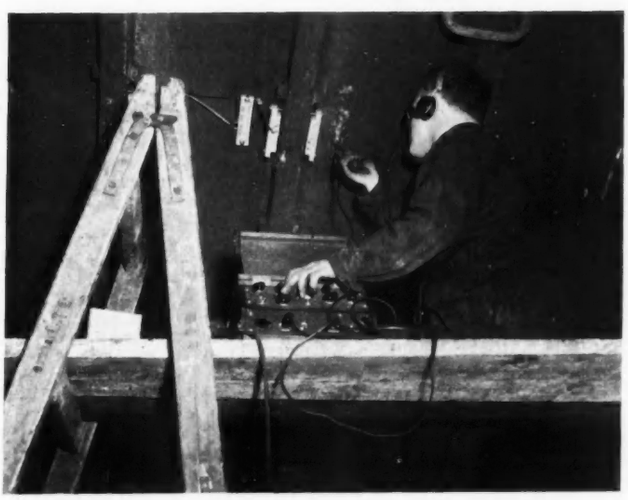
B.R.S. MEASURES INDUCED STRESSES

A cast-iron tunnel lining was first used for the Tower Subway under the River Thames in 1869. It has proved extremely safe and satisfactory and since that time the same type of lining has been used for many miles of London underground railway and in other situations. Maintenance over the years has been almost negligible and only rarely has a lining cracked when a new tunnel has been driven alongside an old one. In spite of this successful record, it is stated in the Report of the Building Research Board for the year 1955 that "there is no rational method of design." The same thickness of lining has been used everywhere in the country at various depths and in all sorts of ground. The conclusion to be drawn from this is that the structural dimensions chosen for the earliest linings were so conservative that they have been satisfactory anywhere. There has been no incentive to improve in design or to inquire into the stresses existing in old linings.



Vibrating-wire strain gauges have been fitted on the tunnel linings of London Transport's Underground railways in an effort to determine the stresses set up.

The Building Research Station has in recent years taken every suitable opportunity to measure the stresses in the linings of existing tunnels. Preliminary observations were made in 1942 during the construction of a London Underground tunnel. More extensive measurements were made in 1952 on two 25 ft. tunnels at a depth of 100 ft. in London clay and the increase in stress after construction was followed over a period of years. During 1955, studies were carried out on a cast-iron tunnel to convey water mains under the River Clyde; it was constructed under compressed air at over two atmospheres. Measurements were also made of the existing stresses in seven tunnels of the London Underground constructed about 50 years ago, and the effect of constructing adjacent tunnels was followed closely. The Clyde Tunnel observations showed clearly the effect of the tide and of the release of the compressed air, but the largest stresses were associated with the operation of caulking the flange joints with lead.



The gauges, with a gauge length of 3 inches, have been screwed directly to the lining. If necessary, they would have indicated possible damage due to adjacent construction work.

The opportunity to measure existing stresses in the 50 years old London Underground tunnels was furnished when it was planned to remove some of the cast-iron linings to enlarge the tunnels at some points. Strain gauges, sensitive to a change in length of one-millionth of an inch, were fitted to the linings before they were disturbed and the changes in length of many parts of the iron were measured after the linings had been removed. In this way it was possible to deduce, in the course of a few months, the stresses that were present in the tunnel linings. The strain gauges used were of the vibrating-wire type with a 3 in. gauge length, screwed directly to the lining. Jigs and templates were used to facilitate the work of drilling and tapping the cast iron, as is shown in the upper illustration. About 50 gauges were installed in each of the seven tunnels and they proved very reliable despite vibration from passing trains.

The observations have provided a mass of data on the behaviour of tunnel linings in stiff clays. It has not yet been fully analysed, but some preliminary conclusions have emerged. In the case of a simple isolated tunnel of a given size constructed in London clay, the most important variable which would have to be taken into account would be the depth at which it lay. It is, however, rare for a simple installation of this kind to form part of the London Underground system. Usually there are two tunnels, the relative positions of which vary and at stations the arrangements may be very complex on account of access passages, stairways and escalators. The observations show that in such situations the interaction of the construction of one tunnel on another is of dominant influence on the stress conditions in the lining.

When a tunnel is dug alongside an existing one, the lining of the latter distorts, a diameter directed towards the new excavation increases but slightly in length; the stress changes can, however, be considerable. These changes keep precisely in step with the progress of the new excavation. Because of these findings, the observational work was considerably extended, at the request of the London Transport Executive, on a station tunnel near which an excavation had to be carried out. The strain gauges were used to give early warning of any possible overstressing of the existing lining and so acted as a valuable additional control on constructional operations.

The stress distribution in a lining attained on the completion of excavation appears to persist indefinitely and there is little evidence of the stiff clay yielding with time. The behaviour of tunnel linings is naturally closely linked with the properties of the London clay, especially with its stress-strain characteristics at very small strains. Tests made on clay samples removed from tunnel works suggest that this clay is significantly stronger and less compressible than borehole samples had indicated: information which is not only of much interest in connection with research work, but is of considerable economic value for future construction in the London area both of tunnels and high buildings.

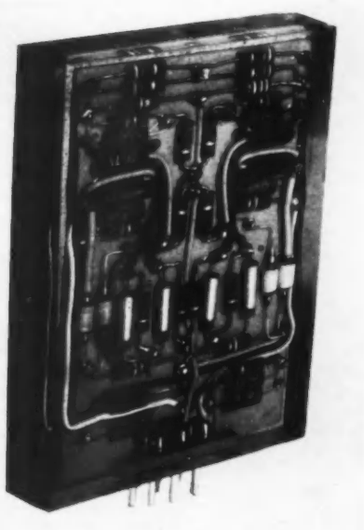
* * *

TRANSISTOR COUNTER

Considerably smaller than the cold-cathode-type counter is the new transistor unit which has been developed by Venner Electronics, Limited, Kingston By-pass, New Malden, Surrey. It can be used either as a stable divide-by-ten stage or in connection with a meter as a counting stage. It employs transistors and germanium diodes throughout, which are arranged in four Eccles-Jordan stages with feedback; the device will count or divide from zero up to 30 kilocycles per second. A single power supply of 10 volts is required; as a scaler the consumption is 100 mW and 160 mW as a counter.

The unit is made up of 86 components, assembled on a double-sided tagboard measuring 4 in. by 3 in. This is then encapsulated in epoxy resin forming a block 4½ in. by 3¼ in. by ¾ in. which in turn is fitted with an eight-pin plug so that the unit can be inserted as a whole. Units may be directly connected to each other without additional components so that by using four in cascade fed from a 10 kilocycle oscillator an output pulse every second can be obtained.

Alternatively, by a different arrangement, a short period timer is obtained for measuring to the nearest 0·1 millisecond, the time for which the switch has been closed. One of the units encased in clear resin for demonstration purposes is shown in the illustration.



The complete decade counter and scaler unit, using transistors, is enclosed in epoxy resin and mounted on a plug. Clear resin is used here for demonstration purposes.

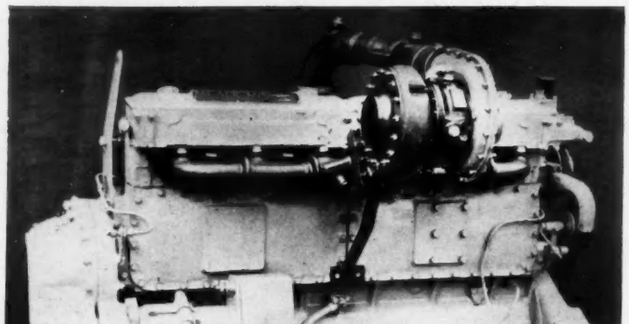


Fig. 1 The 6DCS630 is a supercharged version of an engine that has been proved in use. It has an output of 185 b.h.p. at 1,900 r.p.m. The exhaust turbo-charger has low inertia and responds rapidly to engine changes.

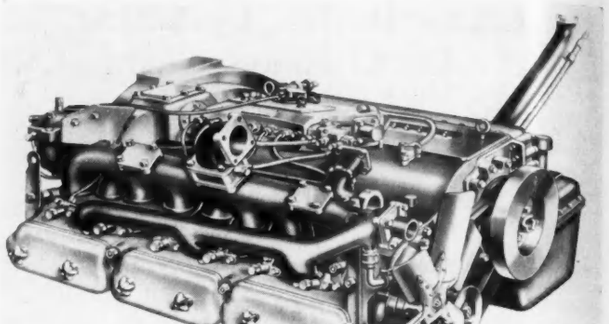


Fig. 2. Available also in a vertical version, the 6DC500 has an output of 135 b.h.p. at 2,400 r.p.m. The cylinders are arranged in groups of two to give interchangeability of parts with other engines in the range.

DIESEL ENGINES FOR HIGH-SPEED ROAD VEHICLES

TURBO-CHARGING, SYNCHROMESH GEARBOXES

Henry Meadows Limited, Wolverhampton, one of the companies forming the Associated British Engineering group, have recently introduced four new engines to improve their range. These four are in the 130/180 h.p. class and have been designed to meet the requirements of high speed commercial vehicles such as will be used on the new motorways.

One of these engines, the 6HDC630, is a horizontal version of one that has been in use for many years, and has now been converted to the under-floor form. It is a six cylinder engine with an output of 130 b.h.p. at 1,900 r.p.m., and has a bore and stroke of 130 mm. It is primarily intended for vehicles of payloads of 15 tons and over or for large passenger vehicles. The 6DCS630 is a turbo-charged version of the same vertical engine and will produce 185 b.h.p. at 1,900 r.p.m. This is for high-speed vehicles of 15 tons payload and over. The turbo-charger used is small and is driven by the exhaust gases. It has been designed and manufactured by Messrs. Eberspacher in Germany and will shortly be available in this country. A particular advantage is that its inertia is very low, and it consequently responds very quickly to changes in engine conditions. A 30 per cent. increase in power is obtained at approximately 20 per cent. increase in cost, which is considerably cheaper than adding another two cylinders to the engine. The makers at present recommend an overhaul of the blower at every 30,000 miles and have arranged an exchange system to operate under these conditions. It is probable, however, that this period will be considerably lengthened in the future.

As with the original 6DC630 engine, both the horizontal and turbo-charged versions work on the 4 stroke cycle and have dry replaceable cylinder liners. The unsupercharged engine has a fuel consumption of approximately 0·37 lb. per b.h.p. per hour. The 6DCS630 is shown in Fig. 1.

The other two engines that have recently been introduced are the 6DC500 and the 6HDC500, which are vertical and horizontal versions of the same model. The horizontal version is shown in Fig. 2. These models have been made with the cylinders arranged in three blocks of two, with the intention of giving better interchangeability of parts throughout the range, for with this plan more parts are suitable for both the four and six cylinder engines. This arrangement allows a smaller store requirement for spares. These two engines are actually six-cylinder versions of the 4DC330 high speed direct injection Diesel engine that has been made by Henry Meadows Limited for some time. Bore and stroke are 120 mm. and maximum b.h.p. is 135 at 2,400 r.p.m. at one hour rating. Fuel consumption at maximum power is 0·406 pint per b.h.p. per hour.

These engines are suitable for installation in commercial vehicles of 12 or 14 tons payload, or passenger vehicles with a seating capacity of 40 to 56. The construction is simple and straightforward, working on the 4-stroke cycle; the sump can be arranged to suit the construction of the vehicle's chassis as required. The valves are unmasked. Forced lubrication at 65 lb. per sq. in. feeds the main end camshaft bearings, rockers and gear drives from a wet sump of approximately four gallons capacity. A filter is included in the oil circuit. On the horizontal engine a scavenge pump is fitted as standard to return excess oil to the sump; this pump can also be fitted to the vertical engine to provide a dry sump system if required. The governor is fitted with a Meadows automatic advance mechanism to control the injection timing in accordance with the engine speed; pneumatic or hydraulic fuel pump governors are available as alternatives. Exhaust discharge can be either centre downwards or end discharge at any angle using the same manifold. All four engines were on exhibition at the recent Commercial Motor Show, together with others of the range.

SYNCHROMESH GEARBOX

Another new development of Henry Meadows, Limited, are five-speed synchromesh gearboxes equivalent to the 250C5 and the 350C5 boxes at present in production. The new boxes use the Porsche system of synchromesh which has enabled them to be kept the same length as the old ones, and therefore to be readily interchangeable. In the first versions the synchromesh will be on the second to fifth gears only, but it is intended at a later date to include the first and possibly also the reverse gear. This inclusion will facilitate remote control of gear changing.

The principle of the Porsche mechanism is shown in the diagram in Fig. 3. The driving members consist of the clutch body (1) shrunk on to the driving gears. The inner face of the body is machined to form a smooth conical clutch face into which fits the synchronising ring (2) consisting of a split spring ring faced on both edges with a mating cone. The synchronising ring is held in position by a supporting ring (3) which is driven round by an internal snug. On the outer diameter of the ring is a projection which fits into the slot of the synchronising ring; the whole of this driving assembly is located in position on the clutch body by means of a

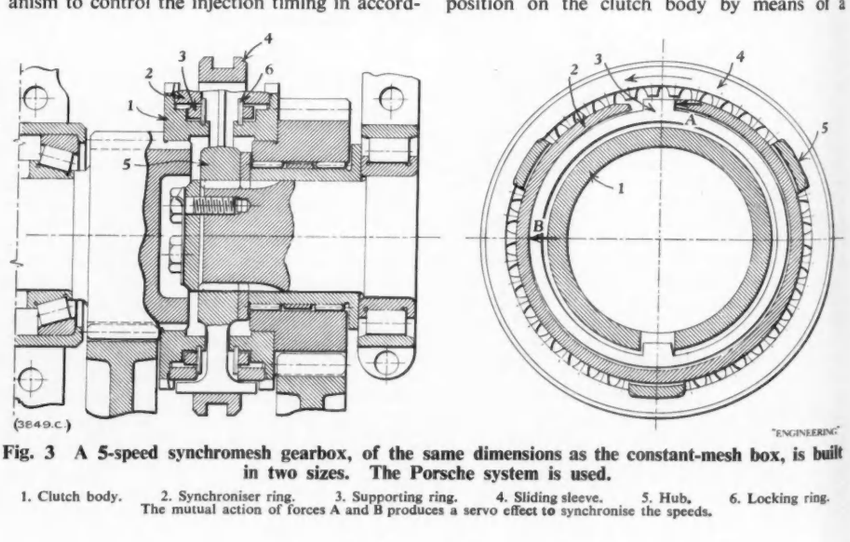


Fig. 3 A 5-speed synchromesh gearbox, of the same dimensions as the constant-mesh box, is built in two sizes. The Porsche system is used.

1. Clutch body. 2. Synchroniser ring. 3. Supporting ring. 4. Sliding sleeve. 5. Hub. 6. Locking ring. The mutual action of forces A and B produces a servo effect to synchronise the speeds.

Circlip (6). The driven members of the gear consist of a star-shaped hub (5) keyed to the driven shaft. The sliding sleeve (4) is held centrally in position by the hub and when fully engaged the drive is transmitted through the gear teeth of the clutch body (1) meshing with the internal teeth on the sliding sleeve, thus driving through the hub (5) to the driven shaft.

On moving the sliding sleeve towards the engaged position, contact is made on the inner diameter of the internal teeth with the male portion of the cone of the synchronising ring. The ring is thus moved into engagement with the inner clutch face of the clutch body and a friction drive is imparted by the driving member to the driven unit. Since relative movement exists at this point, the pressure imparted to the sliding sleeve tends to move the synchronising ring in relation to the supporting ring (3), thus the abutment on the latter unit is forced against one side of the slot in the synchronising ring. This force tends to open the ring and so force the conical faces of the clutch closer into engagement. In this way the relative movement between (4) and (1) is reduced until eventually complete synchronisation occurs. At this point no force is imparted by the abutment to the edge of the split ring at point A, consequently the abutment is free to move within the limits of the slot in the synchronising ring. Therefore the ring can easily be compressed and the sliding sleeve moved over into full engagement. The action of the force on the split ring is such that the higher the load imparted to the sliding sleeve the greater the friction force existing between the cone faces; thus it is virtually impossible for a faulty engagement of the gear to be made inadvertently.

The torque which can be transmitted by these gearboxes is indicated by the first number in the type style. That is, the 250CS5 model can transmit a torque of 250 lb.-ft. The maximum input speed is 2,400 r.p.m. Power take-offs are fitted on both sides of the box.

Three-high cogging rolling mill with a final mill speed of 61 r.p.m. Ingots are cogged down to billets ranging from 3 in. square to 6 in. square.

TOLEDO STEEL CENTENARY

The Sheffield steelmaking firm now known as Andrews Toledo Limited, and, since 1938, a subsidiary company of Darwins Limited, Fitzwilliam Works, Tinsley, Sheffield, 9, celebrates its centenary this year. Founded in 1856 by John Henry Andrew, the firm first occupied premises in Malinda-street, Sheffield, but, in 1866, moved to its present site in Neepsend-lane, Sheffield, 3. In the years which followed, expansion gradually took place. In 1870 twelve crucible furnaces and a forge shop were erected; in the following year bar rolling mills and a wire-rod mill were put into commission and, in 1880, the first open-hearth acid furnace and a spring shop were built. With the passage of time the firm's steels in billet, bar and wire-rod forms, and steel products, such as hammers, picks, shovels and springs, sold under the brand of Toledo, gained a deserved reputation for quality and the firm, then known as Jno. H. Andrew and Co. prospered. In 1898 the concern entitled Jno. Hy. Andrew and Company, Limited, was formed with Lord Charles Beresford as chairman and Mr. Herbert Henry Andrew, the son of the founder, as managing director. It is of interest to note, in passing, that Mr. H. H. Andrew was elected Master Cutler in 1896.

MINING DRILLS

Large quantities of mining-drill steels were sent to Australia for the "gold rush" of the Nineteenth Century, to South Africa for the gold and diamond mines, and to the Balkans and Asia Minor for oil-field drilling. During the war of 1914-18, an electric-arc furnace and new wire-rod mills were installed and gradually the firm concentrated its energies on the production of carbon and alloy-steel billets, and bars for the aircraft, motor-car and engineering industries, and rods for the wire industry, and the manufacture of shovels and other tools and springs ceased in 1928. In 1929 the firm's name was changed to Andrews Toledo Limited, and, in 1938, amalgamation took place with Darwins Limited, one of the oldest firms in Sheffield, having been founded in 1774. Meanwhile, in 1927, a new 12 in. bar mill and, in 1931, a 25 in. cogging mill had been erected. At the present time Andrews Toledo Limited are in a strong position, working to full production capacity with an increasing order book. The firm, in fact, is typical of the Sheffield steelworks which produce the high-grade steels that have given the city a world-wide reputation.

STEEL MELTING PLANT

The Toledo Works melting shop contains three 20-24 ton acid-lined producer-gas fired open-hearth furnaces; two are normally in operation while the third is under repair. The furnaces are charged by means of a Wellman Smith Owen charger having a maximum capacity of 23 cwt. per pan. Melting in the furnace is accelerated by the use of oxygen lancing, the gas being piped from an oxygen tank via evaporators to the furnaces. Molten steel from the furnaces is cast by the uphill or bottom-poured method into either 11½ cwt. or 21½ cwt. ingots, the latter being used occasionaly for forging orders. The casting pit is equipped with a 15 ton and a 7 ton crane. Also situated in the melting shop is a 10 ton Efco Héroult electric-arc furnace, installed some two years ago. The furnace shell has a diameter of 11 ft. 6 in. and the hearth lining consists of graphitised dolomite. The side walls are built up of magnesite tubes and the roof is of silica-brick. The furnace is charged by means of a basket inserted in one load by a 20 ton electric overhead travelling crane. Melting is accelerated by the use of oxygen lancing.

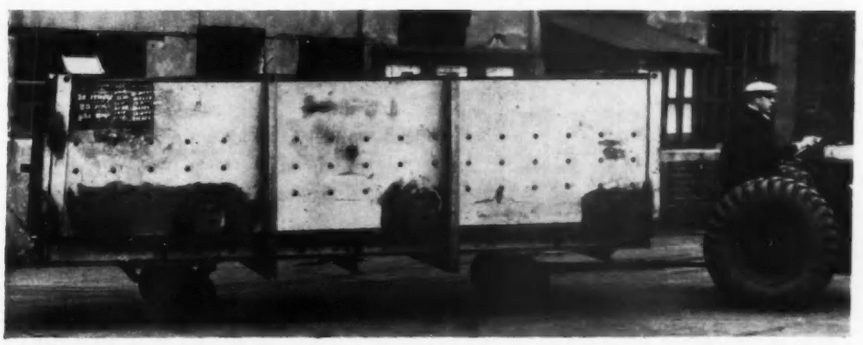
DE-SEAMING

In an adjoining de-seaming department, ingots are surface dressed by means of oxy-propane torches, while a Craven square-turning lathe having a capacity of 11 in. by 4 ft. 6 in., deals with the ingot-surface dressing of steels which cannot be undertaken by the de-seaming process.

The rolling-mill plant comprises a wire-rod mill, a 25 in. cogging mill, and 14 in., 12 in., 11½ in. and 8½ in. bar mills, all of which are electrically driven. The wire-rod mill consists of a three-high cogging stand, a three-high intermediate stand, eight two-high finishing stands and a rod coiling machine. In the 25 in. cogging mill, a general view of which is seen in the illustration above, ingots are rolled down to billets having dimensions of between 3 in. square and 6 in. square. The billets are cut into lengths by a 42 in. pendulum hot saw. The bar mills each consist of a number of stands, producing round bars from 4½ in. to ¼ in. in diameter, hexagonal and octagonal bars measuring from 1¾ in. to ¼ in. across the flats, spring-steel flats and various sections.

The 14 in., 12 in. and 11½ in. bar rolling mills are served by mobile furnaces which transfer finished-rolled special steels to the heat-treatment department. An external view of one of these furnaces is seen below. They are made of steel plate built up on steel-angle frames and are firebrick-lined. They are pre-heated by town gas to a temperature of 450 deg. to 500 deg. C., and the hot bars from the rolling mills are placed in them. The furnace is then hauled by tractor to the heat-treatment department where its contents are transferred, without intermediate cooling, into heat-treatment furnaces, by means of a charging machine. The 8½ in. bar mill is equipped with a slow-cooling tube furnace pre-heated by waste-heat from the oil-fired billet reheating furnace of the mill. The hot finish-rolled material is charged directly into these tubes where it is allowed to cool slowly. The purpose of the mobile and tube furnaces is to control the cooling of the material through critical temperature zones to assist in preventing stress cracking in some of the special and alloy steels treated.

The other departments of the Toledo Works comprise a roll-turning shop in which there are six lathes capable of turning all rolls used in any of the mills; a heat-treatment department containing eight gas-fired furnaces each fitted with an automatic temperature controller and recorder, and two automatic oil-quenching and one automatic water-quenching tank; and a warehouse. The latter is particularly well equipped with bar-reeling and straightening machines, cropping shears, cold-sawing and cutting-off machines. Wet magnetic and other non-destructive crack-detection apparatus for the examination of aircraft and other steels is also provided.



Mobile furnace pre-heated by town gas for the transfer of finished-rolled special steels from the mill to the heat-treatment department. Stress-cracking is thus minimised.

Fig. 1 Bogie of Piccadilly Line driving motor car fitted with Metalastik rubber suspended bolsters and axleboxes.

Fig. 2 Close-up of suspension at axlebox, showing screw adjustment for wheel wear.

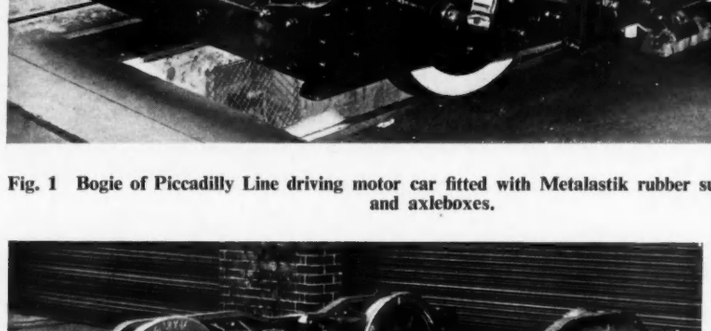


Fig. 3 Bogie of Piccadilly Line trailer car fitted recently with Spencer Moulton rubber suspension on the bolster and axleboxes.

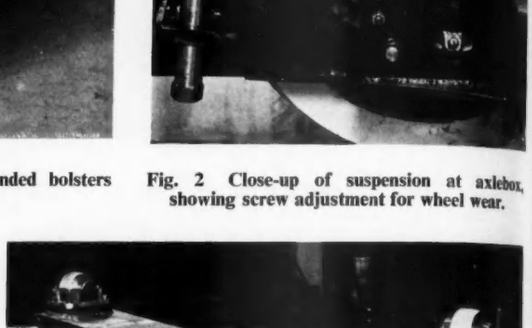


Fig. 4 Bogie bolster removed from bogie, showing rectangular rubber packs.

RUBBER SUSPENSION OF RAILWAY BOGIES

FURTHER EXPERIMENTS BY LONDON TRANSPORT

For nearly ten years London Transport has been carrying out experiments with various types of rubber suspension for the bogies of both tube and surface-line cars with a view to reducing maintenance costs by eliminating all wearing parts, such as rubbing plates, hanger pins and bushes and also steel springs. An interim review of the position was given on page 830 of ENGINEERING for December 25, 1953, when the rubber-suspended bogie bolsters which had been installed on a District Line trailer car in 1947 were described. At that time (1953), the axlebox springing on this car had been converted to rubber suspension and the change had proved satisfactory in service.

These experiments were subsequently carried further by installing a similar type of springing on a Piccadilly Line driving motor car, which entered service in July, 1954. The suspension of this car, like that of the District trailer car, was designed by the Development Division of the Chief Mechanical Engineer (Railways) of London Transport, in collaboration with Metalastik, Limited, Leicester, the arrangement being as described below and illustrated in Figs. 1 and 2.

The bogie bolster, which is normally mounted on coil springs, is supported at each end by two circular rubber packs. These packs are in the form of an inverted V and are inclined laterally so that they will take up all the forces acting on the bolster. With this arrangement the rubber is in both compression and shear. The axlebox suspension was re-designed so that instead of the bogie frame being free to move vertically about the axleboxes under the control of the side springs, the axleboxes were now located on each side by rubber chevrons which are bonded to steel plates (Fig. 2). The assembly is enclosed in a cast yoke, which is bolted to the bogie side frame. The yoke has a screw adjustment on one side to allow for wheel wear.

A NEW DESIGN

Rubber suspension units of different design, which have been supplied by George Spencer, Moulton, and Company, Limited, Ashley-place, London, S.W.1, are now being tried on a Piccadilly Line trailer car. As on the other cars, both the bolsters and axleboxes are rubber sprung, but in this case the bolster suspension units, one of which is illustrated in Fig. 4, consist of rectangular rubber packs supporting a V-shaped bolster. The axlebox suspension, while eliminating the conventional horn guides and side springs, employs the principle of rubber in torsion and shear.

Each axlebox spring unit consists of two fabricated steel arms arranged at about 180 deg., which form a hinge about the axlebox. The two halves of this hinge are bonded together by two rubber rings in compression which surround the circular axlebox. The outer end of each arm is attached to a pivot bracket on the outside of the bogie frame, the pivot material being rubber. The pivot arm nearest the end of the bogie at each position is adjustable in the vertical plane to allow for wheel wear.

Although the two Piccadilly cars ride satisfactorily at speeds up to 45 m.p.h. it has been found desirable to fit shock absorbers to both types of bolster to improve the riding qualities at higher speeds.

* * *

BENCH GRINDER WITH AUTOMATIC TRAVERSE

A bench grinding machine has been developed by the B.S.V. Development Company, 16 Padiham-road, Sabden, near Blackburn, Lancashire. It incorporates an automatic traversing action for the grinding wheel designed to obtain a uniformly consistent grind over the whole face of the tool. The 8 in. diameter grinding wheel traverses to and fro over a distance of 3 in. across the edge of the tool, taking approximately four seconds in each direction. The tool rest is adjustable to suit the tool being ground. A diamond wheel dresser fixed in a screwed shank below the tool rest can be used to trim the wheel when necessary. A heavy load bearing against the grinding wheel increases the traverse speed.

* * *

ELECTRICITY SUPPLY

During August, 1956, 4,876 million kWh were sold by the Central Electricity Authority to the English and Welsh Area Boards. This was an increase of 10·7 per cent. over the figures for August, 1955, but when corrected for weather and working days the increase was 7·3 per cent.

The amount of electricity sent out by the Area Boards during the same month was 4,694 million kWh, and 182 million kWh were supplied direct by the Central Authority. The increases in the amounts sent out, compared with the corresponding figures for August, 1955, were 7·3 per cent. in the " mainly industrial " and 16·9 per cent. in the " mainly non-industrial " areas.

ATOMIC REVIEW

Sites and Science

Factors in siting nuclear power stations—Effluent disposal—Extracting pure water from underground in large quantities—Extended surface for heat-exchanger tubes—Novel fuel element—Heat transfer in boiling liquids—Storing liquid nitrogen—Use of liquid gases in research—Nuclear cooling—Reactor news—Domestic heating—Graphite welded for the first time—Nuclear congress—Uranium mills—Longevity and cosmic rays.

Power Station Siting

One of the more important advantages of atomic over conventional power stations is their flexibility with regard to siting. The cost of transporting nuclear fuel is negligible and a station supplied initially with fuel can run for years in almost total isolation. Conversely, while coal is still economically competitive with nuclear fuels, there is good reason to locate atomic power stations in areas where coal is not immediately available. This appears to be the present attitude of the Central Electricity Authority, for its chairman, Lord Citrine, has recently stated that in siting such stations preference would at first be given to districts where there was no coal supply. However, fuel is not the only consideration in siting, and stations must generally have means of disposing of wastes and effluents, though radioactive wastes will probably continue to be treated at Windscale, and also an adequate water supply for condenser cooling and feed-water make-up.

Wastes and Effluents

The problem of discharging atomic waste has been dealt with in a paper presented before the Institution of Civil Engineers in conjunction with the British Nuclear Energy Conference on September 25 by Mr. F. R. Farmer. Mr. Farmer, who is Senior Production Control Engineer, United Kingdom Atomic Energy Authority, Industrial Group Headquarters, Risley, near Warrington, Lancashire, spoke on "The Problem of Liquid and Gaseous Effluent Disposal at Windscale." The author showed the choice of piles and chemical processes to be partly dependent on their respective effluents, and that the Windscale site was selected to permit reasonable flexibility in effluent discharge. He also discussed the effect on the environment arising from discharges made during initial plant operation, and concluded that under carefully controlled conditions active materials could be released without infringing the recommendations of the International Commission on Radiological Protection. In fact, the efflux of radioactive gases had been reduced to one-tenth of the tolerance levels specified by the Commission, and tests over five years had shown that there was no hazard to marine or human life from the discharge of the plant's liquid effluent into the sea.

Considerations of waste disposal played a major part in choice of site and an isolated coastal area was selected. However, water could not conveniently be used for reactor coolant since it would have to be extremely pure and in very large quantities; moreover, in the event of a ruptured fuel element, water would become highly radioactive. A gas, in this case air, was therefore chosen. In addition, air did not absorb neutrons to any great extent and so could not cause sudden changes in reactivity. However, it was essential to ensure that dust was excluded from the system and that the aluminium fuel cans were scrupulously clean. A severe hazard would arise if a fuel can ruptured and radioactive products entered the coolant stream; three sets of scanning or detecting devices gave warning if this should occur. In calculating the chimney height necessary to give adequate dispersal of gaseous products wind-tunnel tests were carried out, and other problems were solved by means of models.

Liquid effluents presented a somewhat more serious problem and investigations of tidal movement with fluorescein dye, and of the build-up of radioactivity in marine creatures and plants as far away as 20 miles were performed over long periods. The main process plant contained the highest effluent risk, as several hundreds of thousands of curies of activity would be held in its tanks, process vessels, and pipes. A failure of a weld could release more activity into the building than the effluent plant could handle in one year, so that leakage into surface drains could be a calamity, and into the active effluent drains could render these and the treatment plant so active that continued operation might be impossible for a long period. Thus the whole process plant was tanked at ground level with a continuously welded stainless-steel sheet. The capacity of the tank so formed was sufficient to retain the whole liquid content of the process plant. The only means of emptying it was by a suction lift into an adjacent holding vessel. Fig. 1 shows the active drainage system at Windscale, which involved gravity flow in cast-iron and stainless-steel pipes mounted in concrete ducts.

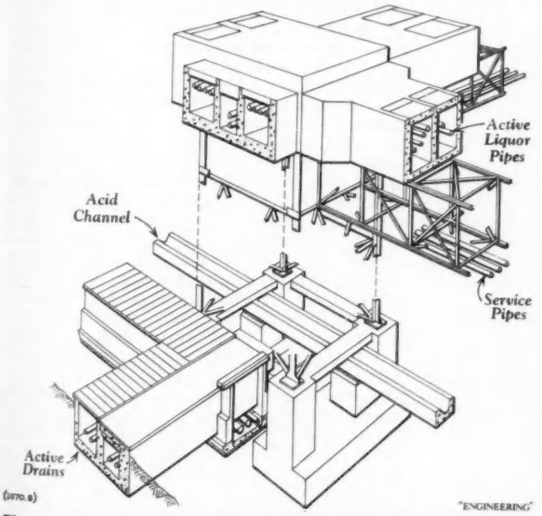


Fig. 1 Active drainage system for the Windscale plutonium producing piles. By careful design and siting of nuclear plants, gaseous and fluid effluents can be discharged without hazard.

It should be noted that one millionth of a curie of many radioactive materials was potentially lethal, so that the problems involved in designing such a treatment plant were necessarily formidable. However, by long-term storage to allow radioactive decay, by concentrating products to relatively small bulk and subsequent burial in sealed containers or disposal in the depths of the sea the problem could be solved. The accompanying table, which has been taken from a paper "The Disposal of Waste Waters and Gases in a Nuclear Power Programme" presented at the World Power Conference by H. J. Dunster, D. R. R. Fair and A. S. McLean of the U.K.A.E.A., classifies typical waste products according to character, safety and treatment.

THE CLASSIFICATION OF TYPICAL WASTES

Source		Type	Safe						Unsafe
			Release						
			No treatment	Dilution		Concentration			Permanent storage
				Simple	Temporal	Filtration	Scrubbing	Chemical	
Reactors	Coolant	Gaseous	•	—	—	•	—	—	—
	Pond water	Liquid	•	—	—	—	—	—	—
	Decontamination	Liquid	•	•	—	—	—	•	—
Chemical plant	Primary separation	Gaseous	•	—	—	•	•	—	—
	Primary separation	Liquid	—	—	•	—	—	•	•
	Fuel purification	Liquid	—	—	•	—	—	•	—
	Decontamination	Liquid	•	•	—	—	—	•	—
Miscellaneous	Ventilation	Gaseous	•	—	—	•	—	—	—
	Laboratories	Liquid	•	•	•	—	—	•	—
	Decontamination	Liquid	•	•	—	—	—	•	—

Water from the Ground

So far the sites chosen for stations in the United Kingdom are within easy reach of the sea; as has been suggested, this may have been largely to provide easy means of effluent disposal, but possibly too for reasons of remoteness—security and a desire to convince the public of the inherent safety of these stations before siting them near centres of population are probably contributory factors. In the future, however, water may not be so accessible; the use of sea water may be excluded owing to corrosion and the cost of purification plant, or direct piping may be inconvenient; and it has recently been reported that the French Commisariat à l'Energie Atomique has resorted to other means of securing water at their Marcoule site. The system adopted is known as the Ranney method of induced infiltration, and the one installation is stated to draw some 310,000 gal. per hour through aquiferous or water-bearing underground deposits by infiltration from a small river nearby.

The method involves the extraction of pure water from shallow alluvial deposits, using the gallery principle but avoiding the construction difficulties arising from this approach. In addition better development of the aquiferous material is obtained. It entails sinking a reinforced concrete caisson, usually about 13 ft. in internal diameter, from the bottom of which screens (sometimes called laterals) are driven horizontally like the spokes of a wheel, as indicated in Fig. 2. These screens, one of which is shown being extended in Fig. 3, comprise perforated steel pipes which, if sections are added as the pipe is forced from the caisson, can be made to reach in a straight line as far as 300 ft. from the central unit. The pressure of the water in the alluvium matrix causes a flow into the caisson, and the caisson serves as a clear well from which water can be pumped. The entire installation is known as a Ranney "Horizontal Collector."

The screens, which are normally in 8 ft. sections, are forced out into the water-bearing stratum by hydraulic jacks, and further sections are welded, or in some cases in America, screwed on as the operation proceeds. First sand and silt are removed through the screens which thus become surrounded by coarse gravel through which water can percolate. Water is drawn

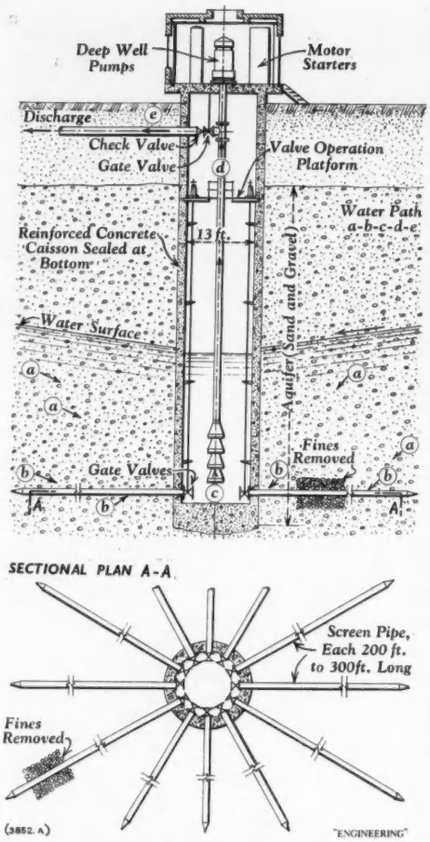


Fig. 2 The Ranney Horizontal Collector enables water to be drawn from alluvial water-bearing deposits through perforated sleeves disposed radially about a central caisson or well.

from the alluvium by way of the screens into the bottom of the caisson and as much as 16 million Imperial gallons per day can be obtained from a single unit. The screens may be 8 to 12 in. in diameter, but a 24 in. screen is made which can extend 450 ft. so providing an infiltration gallery for use under a river bed—two screens running in opposite directions parallel to the river would utilise over 900 ft. of the river's course. This arrangement is an alternative to the radial disposition of the screens. For drawing water from sand formations, fine slotted screens surrounded by artificial gravel packs have been developed. Advantages of the system are that, unlike orthodox wells, Ranney units can utilise the entire depth and extent of the aquifer; water is effectively filtered before it reaches the caisson; and the water collected may be more than 10 deg. C. below surface-water temperature—this may be useful where the water is required for cooling. These units may also prove valuable for plants in which heavy water is separated from natural water and it is understood that they are in use for this purpose in the United States. The company holding the licence for the United Kingdom and Commonwealth is Ranney Method Water Supplies Limited, 12 Queen Anne-street, London, W.1.

Heat Exchangers

Mr. F. M. Greenlees, of the United Kingdom Atomic Energy Authority Industrial Group, in a paper presented before the Institution of Production Engineers, gave as his opinion that "the design of heat exchangers can be considerably improved and cheapened." He said that the stud-tube extended-surface heat exchanger used at Calder Hall had the tremendous advantage that it was already established industrially and was in mass production. The stud-tube extended surface was not, however, ideal for the absorption of heat from an entirely pure gas. The weight of the Calder Hall heat exchangers was also a disadvantage and there was no doubt that a cheaper, lighter and more compact design could be developed. Already, no doubt, the four industrial groups which recently presented their tenders for the C.E.A. atomic power stations have evolved improved methods of manufacturing at reasonable cost lighter and more efficient heat-exchanger elements.

Another form of extended surface is illustrated in Fig. 4, which shows the section of a standard unit developed by Carter Craft Incorporated, of Dallas Texas, for the United States Atomic Energy Commission. The longitudinal fins are bonded to the tube by a continuous Heliarc welding process in which the tubes and fins are held in an upright position while the welding head is traversed vertically on an elevator platform. The strength of the tube is not impaired by cutting grooves for the fins, which are merely formed to shape and fusion welded in position. Metallurgical faults due to excessive temperatures are avoided by use of liquid cooling. Stainless steel, copper alloys and various other materials may be employed, and also dissimilar materials for tube and fins. The patent for this process is held by Alco Products Limited, who have developed, and make in their Beaumont plant in Texas, a double-pipe heat-exchanger unit known as the "Alcotwin." The unit

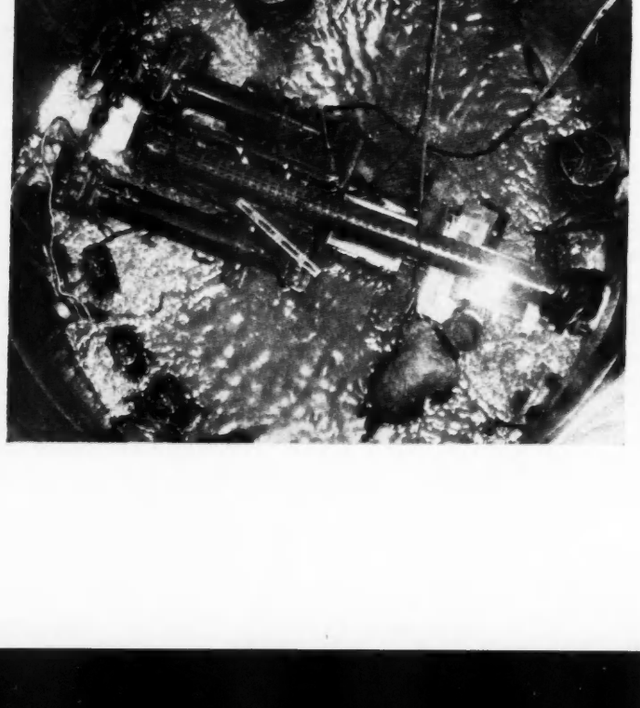


Fig. 3 The perforated sleeves of the Ranney Horizontal Collector are forced out into the water-bearing stratum by hydraulic jacks and successive 8 ft. sections welded in place as the sleeve is extended.

Fig. 4 The "Alcotwin" double-pipe heat-exchanger unit, which can be assembled with other units in series or parallel combinations, employs the concentric-tube principle. Longitudinal fins are welded to the inner tube by a process known as Heliarc. (3634. G.)

comprises the standard finned tube, contained in an outer concentric pipe, and can be assembled with other units in series or parallel combinations. High heat-transfer performance, flexibility and economy are claimed as the advantages of this system.

Fuel Elements

Last week we made passing reference to fuel rods and illustrated the MTR and DIDO-type fuel elements which consist of an assembly of uranium-aluminium alloy plates clad in aluminium. The problems of fuel usage, heat transfer, strength and convenience of fabrication and processing make the development of fuel elements an important priority, and this week we draw attention to a further design, described at a meeting of the American Nuclear Society. The fuel element is to be used in an existing reactor at the Brookhaven National Laboratory, and the aim is to raise the neutron flux without decreasing the effective volume of the reactor. It is also hoped that operating costs will be cut and operation simplified. It is considered that the present natural-uranium fuel element has reached its limit of 500 deg. C. internal temperature. The new element will be fabricated from an aluminium-uranium-alloy aluminium-clad sandwich formed and welded to the shape represented in section in Fig. 5. Each element will be 2 ft. long and comprise three plates bent as shown, each $3\frac{1}{8}$ in. in developed width and 0·060 in. thick. The total content of uranium in an element will be 15·3 gm. and the shape chosen is such as to give a maximum metal temperature of 350 deg. C. The maximum temperature of the graphite moderator will be 225 deg. C. The extremities of the element plates are curled to fit the 2·67 in. diameter channels in the graphite. Power output will remain at 20 MW, but thermal flux will rise to 2×10^{13}. It is believed that the new arrangement will permit a considerable cut in pressure losses thus saving pumping power. It would be interesting to know if a similar cross-section and form of construction has been considered for heat-exchanger tubes.

Boiling Heat Transfer

It is apparent from the foregoing that heat transfer is of major importance in nuclear power plant design and plays a significant part in overall efficiency. Some factors concerned in boiling heat transfer were considered in a paper presented before the Engineering Section of the British Association by Mr. J. McNeillis. It is well known that when heat is transferred from a solid surface to a liquid and the liquid boils, it is possible to obtain a higher heat flux than is the case with single-phase heat transfer. Thus boiling heat transfer finds many applications where high heat fluxes are encountered, including radiation-heated steam generator tubes and nuclear reactors. With boiling heat transfer, however, there exists a critical heat flux which, in general, it is unsafe to exceed and which occurs when the surface being cooled becomes covered with a film of vapour. If the surface generates its own heat, as when electrically heated, the high thermal resistance of the vapour film formed will cause the surface temperature to rise rapidly and the heater surface may melt. At present it appears that with boiling, it is possible to obtain an increased heat transfer coefficient (with increase in temperature) but the maximum heat flux attainable is limited by the formation of vapour film at the surface. Many attempts have been made to correlate the

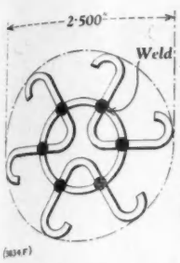


Fig. 5 Fuel elements can assume a variety of forms and this unit for a reactor at Brookhaven National Laboratory comprises aluminium-clad uranium-aluminium-alloy plates bent to shape and welded together. Heat removal is said to be more effective than with standard plate or rod elements.

available data so that the heat-transfer coefficient and critical (or " burnout ") heat flux can be predicted, with some success. There is, however, a further complication possible because under certain conditions the flow of a boiling liquid in a tube or similar duct may be unstable. The presence of unstable flow causes a reduction in the heat-transfer coefficient and may cause burnout of the heated tube at a lower heat flux than that predicted. It is, therefore, important to be able to forecast these conditions under which unstable flow will occur. The author discussed the various phenomena associated with boiling heat transfer and considered the problem of unstable flow.

Nitrogen Storage

The growth of scientific research, especially in the field of atomic energy, has led to increased demand for liquid nitrogen and consequently means of storing it. Consumption has risen in some establishments to several gallons per day and storage by flasks and bottles has therefore proved inadequate. To overcome this difficulty, W. P. Butterfield, Limited, P.O. Box 38, Shipley, Yorkshire, have produced a liquid-nitrogen storage tank of 300 gal. capacity. It is illustrated in Fig. 6. The liquid nitrogen is stored at a temperature of — 196 deg. C. and this requires suitable insulation, the efficiency of which is not impaired by the necessary filling and other connections. Conduction generally and radiation from the jacket to the storage vessel are the main means of heat transfer tending to vapourise the liquid. To limit conduction, materials of low conductivity have been chosen for the fittings and supports and their cross-sectional area reduced as far as possible. Since the surface area of the storage vessel is large, conduction through the insulating medium must be negligible. Vacuum jackets are a common from of insulation for vessels, but, although such a jacket would almost eliminate conduction, there would still be radiation from the jacket to the storage vessel. The inner vessel might instead be surrounded by an insulating powder, giving a considerable reduction in radiation, but conduction of heat through the powder would then exceed that permitted.

These factors were considered in choosing a design, and the result is a vessel and fittings of stainless steel contained in a mild-steel jacket. Insulation is by means of both powder and vacuum so that radiation and conduction losses are each reduced to a minimum. The air pressure is about 0·1 mm. of mercury and tests conducted on a 300 gal. tank show an evaporation rate of only 0·66 per cent., or approximately 2 gal. per day. The rate of air leakage into the jacket is negligible and it is unnecessary for a vacuum pump to be in constant use. In addition to the 300 gal. vessel, others can be made.

Liquid Gases in Nuclear Physics

In our issue of July 27 (page 124) we described the method by which the first photograph showing atoms as discrete entities was taken. We reproduced the photograph on page 125. The apparatus included a field ion microscope and involved the use of temperatures in the region of — 180 deg. C. These were achieved by using liquid nitrogen. The laboratory use of liquid nitrogen and liquid oxygen (boiling point — 183 deg. C.) as refrigerants is widespread. They are largely interchangeable though the boiling point of nitrogen (— 196 deg. C.) is somewhat lower than that of oxygen, and oxygen must of course be excluded where inflammable materials are present. The primary use of liquid nitrogen in a research laboratory is to enable the scientist to extend the range of any physical measurements to lower temperatures. Even quite bulky apparatus can be enclosed in a Dewar flask and surrounded by a bath of liquid. In general where liquid nitrogen is stored in a large insulated vessel, the quantity required for daily use may be extracted in metal Dewar flasks (capacity 5 gallons, say) and transferred from these into ordinary " Thermos " flasks for use in the laboratory. In this way the advantages of low evaporation rate in the main storage vessel and convenience of handling in small flasks may be combined.

Liquid nitrogen serves a variety of technical purposes. It can be used for cold traps to condense vapours in high-vacuum systems, mercury vapour, for example, in systems employing mercury diffusion pumps, though the growing popularity of oil diffusion pumps has to some extent reduced this application. Cold traps are, however, of the greatest value in high-vacuum systems for the isolation of secondary pressure gauges (Pirani, ionisation, Penning and others) from the rest of the system. Condensable vapours are thus prevented from reaching gauges which might otherwise give spurious readings. In the purification of helium, hydrogen and neon a cleaner employing finely divided charcoal cooled with liquid nitrogen is used to remove the last traces of air from the gases, as air is strongly adsorbed on the surface of the charcoal at very low temperatures.

Probably the most important application of liquid nitrogen is to the production of liquid hydrogen and helium by means of which temperatures as low as —253 deg. C. and —269 deg. C. respectively can be achieved. These gases are pre-cooled by the liquid nitrogen in a liquefier to economise in the quantities of the other liquids required. If hydrogen gas is suitably cooled it will cool itself still further and finally liquefy by expanding through a nozzle from a high to a low pressure. The liquid hydrogen is in turn used directly in many problems in nuclear research. Fundamental information about the nature of the forces acting in a nucleus can be obtained by studying the bombardment of liquid hydrogen by beams of very energetic particles such as protons, neutrons and mesons. In another application liquid hydrogen is used in one of the newest and most successful methods for detecting nuclear particles—the hydrogen bubble chamber (see ENGINEERING, vol. 181, page 444, 1956). This chamber also requires a considerable supply of liquid nitrogen, to keep the loss of liquid hydrogen due to heat inflow to a minimum. This account has been compiled from information supplied by Dr. J. M. Lock of the Ministry of Supply Radar Establishment, St. Andrews-road, Great Malvern, Worcestershire (who with Dr. D. H. Parkinson and Mr. W. A. Moyes assisted in the design of the liquid-nitrogen storage vessel previously described) and Dr. R. G. P. Voss of the University of Liverpool, Nuclear Physics Research Laboratory, Mount Pleasant, Liverpool 3.

Fig. 6 Butterfield liquid-nitrogen storage vessel. Combined powder and vacuum insulation minimises both heat transfer by conduction and by radiation from the jacket to the inner vessel.

Nuclear Cooling

In an article published in *Nature* (September 1, page 450), Dr. N. Kurti, F.R.S., Dr. F. N. H. Robinson, Sir Francis Simon, C.B.E., F.R.S., and Mr. D. A. Spohr, have described experiments carried out at the Clarendon Laboratory, Oxford, on the subject of " Nuclear Cooling." They state that in various laboratories temperatures of the order of 1 millidegree above absolute zero have already been reached by the magnetic cooling method using the isentropic demagnetisation of an electron paramagnetic substance. However, the lowest temperature which may usefully be achieved in this way is limited by the presence of interactions (dipole-dipole exchange and others) between the electron spins. Soon after the first successful magnetic-cooling experiments it was suggested that by demagnetisation of nuclear spins much lower temperatures might be reached at which the nuclear spins would become ordered. The object of the recent experiments has been to effect an appreciable reduction of entropy in a nuclear spin system by an external magnetic field, and so to obtain information about nuclear interactions in solids by measuring the temperature reached on subsequent demagnetisation. Nuclear cooling involves the following steps. The nuclear paramagnetic substance is magnetised in a large field and the heat of magnetisation absorbed by a thermal sink at 0·01 deg. K. or thereabouts. The field is then reduced to zero, when, if the process occurs adiabatically, the nuclear spins cool to a temperature determined by the initial temperature, the applied field and the nuclear interactions. In addition to confirming that by using nuclear demagnetisation, temperatures could be attained below those accessible with electron paramagnetics, the experiments furnished direct evidence of the interactions between nuclei in metals. The experiments are to be continued.

Reactors

The U.S.A.E.C. has awarded a one-year contract to the Battelle Memorial Institute for critical assembly studies on the range of usefulness of a control system for a heterogeneous boiling-water reactor in which the normal function of control rods is taken over by the reflector.

The Yankee Atomic Electric Company has signed a contract with the Westinghouse Electric Corporation covering the development and design of the nuclear reactor for their atomic power plant at Rowe, Massachusetts.

Soviet scientists have referred to plans for a gas-cooled heavy-water moderated reactor in which an additional concentric coolant passage keeps the moderator at a temperature below 100 deg. C. The gas outlet temperature is 450 deg. C. and the coolant is under high pressure.

Heating

Dr. F. J. Larsen, research director of the Minneapolis-Honeywell Regulator Company has said that it may not be long before atomic fuels are used for domestic heating, with heat supplied from central stations serving whole communities. The stimulus to using nuclear energy in this way

would come from an increase in electrical load problems in homes and the eventual shortage of other fuels. He did not consider the prospects for individual household reactors very bright, though a rudimentary reactor might be contained in a pressurised container not much larger than a five gallon can. However, the necessary shielding would require a volume greater than the average basement, and in any case such a unit would be extremely uneconomic in the cost of both plant and fuel.

Direct use of reactor heat piped by hot gases or liquids to homes and factories would clearly be more economic in many circumstances than the double conversion into electric power and back to heat again. It is thus interesting to learn that Sweden is carrying out work in this field with nuclear heating stations as the object. Norway is reported to be planning to use nuclear heat for the wood-pulp and paper industries, and high-temperature reactors are said to be under consideration for such applications as the gasification of coal (ENGINEERING, vol. 181, page 245, 1956), for chemical processing, and other industrial activities.

Welding Graphite

The National Carbon Company of Cleveland, Ohio, recently announced that they had succeeded in melting and welding graphite for what is believed to be the first time in history. An official of the company suggested that this development might lead to the prefabrication of sheets and panels for the assembly of nuclear reactor moderators, which are now built from graphite blocks.

Notes and Notices

Sir Edwin Plowden, Chairman of the United Kingdom Atomic Energy Authority, and Sir John Cockcroft, Director of the Atomic Energy Research Establishment at Harwell, left for America recently to attend a discussion on the economic aspects of nuclear energy which is being held as part of this year's meeting of the International Bank. Admiral Strauss, Chairman of the United States Atomic Energy Commission, is also taking part.

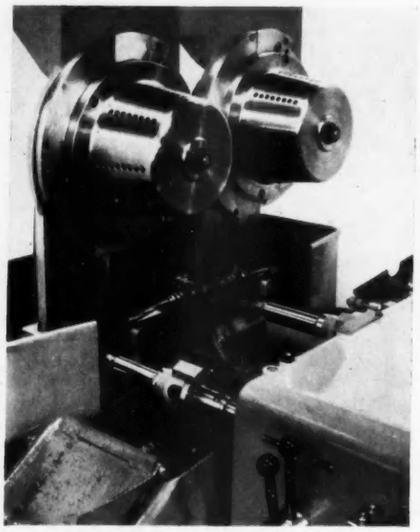
An international nuclear congress is to be held at Philadelphia, Pennsylvania, U.S.A., next March. Dr. Walter G. Whitman, who was secretary-general of the Geneva Atomic Energy Conference last year, will be general chairman of the congress.

The U.S.A.E.C. has stated that uranium mills are being considered for New Mexico, Utah, Colorado, Wyoming and Washington. It is also said that the total number of mills in the United States may be doubled by 1958.

The Soviet Union is reported to have disclosed the location of an "atomic city." It is at Dubna on a river of the same name near the starting point of the Volga-Moskva Canal, about 75 miles north of Moscow. A 400 MW nuclear power station to be built near Moscow (see ENGINEERING, vol. 181, page 444, 1956) may well be sited at Dubna.

Postscript

A report from the recent International Astronautical Federation Congress, that black mice taken to a height of 20 miles and exposed to cosmic radiation turned grey and white in patches after a few hours, recalls a wild theory put to us by a wild young man who may or may not have got something. He suggests that a contributory factor in the deterioration of human tissues with age may be the effect on living cells of cosmic radiation. Thus, he says, if it weren't for anthracosis and silicosis, miners would probably live longer than the rest of us, if not for ever. However, whatever harmful effects cosmic radiation may have, it seems likely that it also has some beneficial effect without which life would curl up and die. What is more, the two effects, good and bad, are no doubt inextricably associated. After all, that's life. In any case, what price longevity and the Brothers Barnabas, when within a year or two we shall be able to take a space flight and come back to find our friends in history books?



When the hinged safety guards of the Kosfeld nut-tapping machine are opened the tap is immediately accessible, and can be changed quickly. The machine shown has two spindles, and the drum-type feeders are clearly visible.

AUTOMATIC NUT TAPPING

Magazine Feed and Quick Tap-Change

The Kosfeld automatic nut-tapping machine, which is made by Friedrich W. Kosfeld, Brackwede, Westfalia, Germany, has recently been re-designed, and now incorporates a number of new features, including a new drum-type feed magazine. Alfred Herbert, Limited, Factored Division, P.O. Box No. 18, Red Lane Works, Coventry, have been appointed sole selling agents for the machine for Great Britain.

The Kosfeld machine, which is available as either a single-spindle or a double-spindle model is based on the well-known "bent tap" principle, in which the nuts, when tapped, pass along the shank of the tap, which rotates continuously. At some distance above the screwed portion of the tap, the shank is turned through 90 deg., with a relatively large radius, so that the nuts can pass off the end into a chute for disposal. The tap floats loosely in a tapping head, being located by the line of nuts on its shank. It is rotated by means of the "bent" end, and the tapped nut which is in the act of leaving the tap, and is in contact with the rotating head. The tapping head is connected to the driving spindle by a quick-acting lock, which is operated by hand, and taps can thus be changed very quickly. A spring feed is used on the tapping spindle, which ensures sensitivity in the tapping operation.

The feeding mechanism is a recently-designed feature of the machine. It consists of a hopper, which is filled with nut blanks by hand, and a rotating drum, which sorts out the components and delivers them, correctly aligned, to a feed chute. From this point the blanks are taken mechanically, one by one, by a lateral slide, and presented to the tap.

The machine has independent motor drive, and there are three tapping speeds for the spindle with hand-lever control through totally-enclosed gears running in an oil-bath. On the two-spindle machine each spindle operates independently, and it is possible to tap two sizes of nut at the same time if required. Safety devices are built into each spindle mechanism for protecting the tap against damage from such causes as faulty nut blanks, with badly displaced holes, or without holes at all. The spindle will stop automatically if it encounters an obstacle of this type, or if a nut of the wrong size should be fed with the blanks.

There are five sizes of machine, covering tapping from $\frac{1}{4}$ in. to 2 in. diameter Whitworth, each machine in the size being suitable for tapping three sizes of nut. Hourly outputs vary, of course, according to the size of the machine; typical figures are, for the smallest machine, $\frac{1}{8}$ in., $\frac{3}{16}$ in. or $\frac{1}{4}$ in. nuts at 2,400, 1,800 and 1,500 per hour respectively. At the opposite end of the range is a machine capable of tapping $1\frac{1}{4}$ in. nuts at a rate of 180 per hour, $1\frac{1}{2}$ in. at 150, and 2 in. at 120 per hour. These rates of output are for the single-spindle machine, and are of course doubled when there are two spindles.

The machine can be modified if necessary, to meet special requirements. It can, for example, be fitted with a reversing spindle for tapping blind holes and for other applications which cannot be dealt with by the ordinary "bent" tap. A similar type of machine, modified to carry out de-burring and facing of nuts, is also available.

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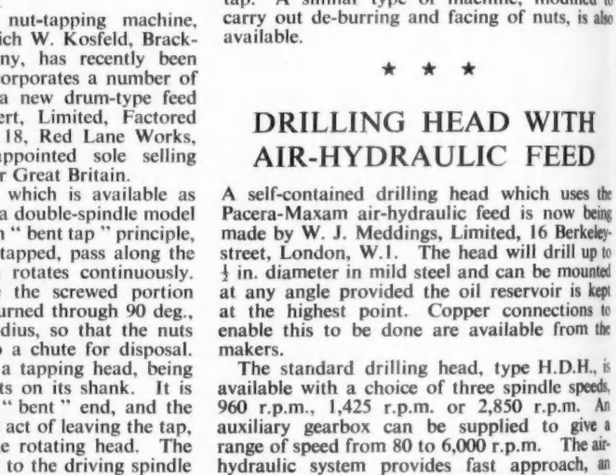
DRILLING HEAD WITH AIR-HYDRAULIC FEED

A self-contained drilling head which uses the Pacera-Maxam air-hydraulic feed is now being made by W. J. Meddings, Limited, 16 Berkeley-street, London, W.1. The head will drill up to $\frac{1}{2}$ in. diameter in mild steel and can be mounted at any angle provided the oil reservoir is kept at the highest point. Copper connections to enable this to be done are available from the makers.

The standard drilling head, type H.D.H., is available with a choice of three spindle speeds, 960 r.p.m., 1,425 r.p.m. or 2,850 r.p.m. An auxiliary gearbox can be supplied to give a range of speed from 80 to 6,000 r.p.m. The air-hydraulic system provides fast approach, an infinitely variable feed and slow break-through with fast return, if required. The head has a $1\frac{1}{2}$ in. stroke, and adjacent heads can be mounted on 7 in. centres. One of these units is shown in the illustration below.



This drilling head has an infinitely variable rate of feed operated by an air-hydraulic system.

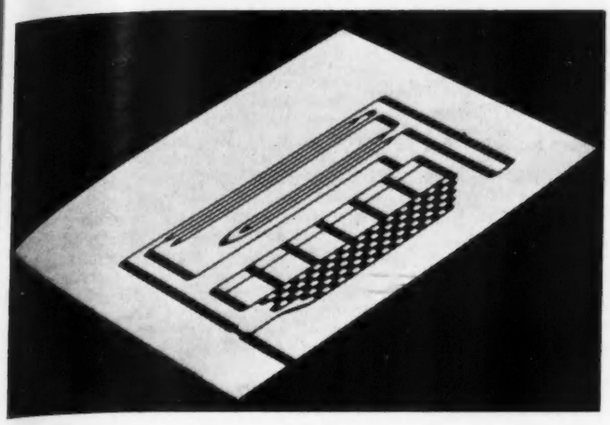


Fig. 1 The Kynal heat-transfer panel is made up of two flat sheets and on the surface of one the pattern of tubeways is silk-screened in "stop-weld" ink. The pattern is compressed to allow for elongation in rolling.

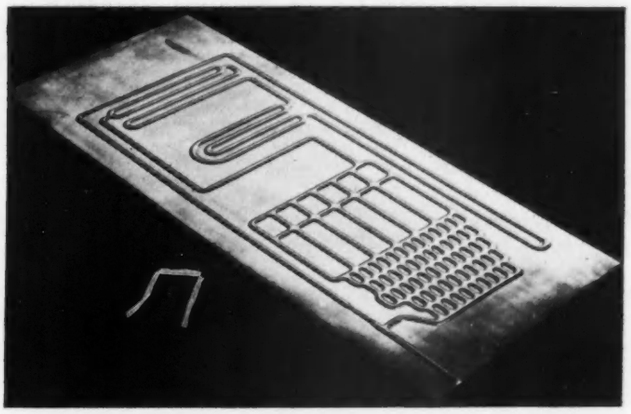


Fig. 2 The two sheets are welded together by cold rolling except where the stop-weld ink is present. The tubeways are then formed by inflation at high pressure.

HEAT EXCHANGERS MADE BY A NEW METHOD

PRINTED PATTERNS ON ALUMINIUM SHEET

Many methods have been employed for combining a metal tube and a sheet so as to provide a large surface area for heat transfer, and one of the latest is that being used by Imperial Chemical Industries, Limited, Metals Division, Witton, Birmingham, 6, in which a system of tubeways constitutes an integral part of the aluminium cold-roll-welded panel, seen in Fig. 2. The process begins with a photographed drawing of the tube arrangement required. It is emphasised that any system which can be drawn on paper can be produced in the final aluminium sheet and that multiple paths and tube junction are no more difficult to form than straight tubes.

The panel commences its life as two separate sheets of Kynal P.10 aluminium, each thicker than the final product. Kynal P.10 aluminium, it may be noted, is equivalent to material S1C of British Standard 1470. The pattern of tubeways, compressed in one direction to allow for subsequent elongation during cold rolling, is silk-screened on to one sheet, as shown in Fig. 1, using a special "stop-weld" ink. A second sheet is then placed against the printed one so that the printed surface is sandwiched between the two sheets, which are then cold-rolled together. Owing to the very high contact pressure produced during this operation, the two sheets become welded together, except where the stop-weld ink is present. To impart full strength to the weld the sheets are then annealed, during which process recrystallisation of the metal structure occurs. Micro-examination shows that the finished product is virtually one homogeneous sheet, the crystal structure extending across the junction between the two sheets.

The stop-weld ink vaporises at the annealing temperature and escapes from the unwelded portion between the sheets where the tubeway system reaches the edge of the sheet. The pattern is designed to provide this outlet for the vapour and, when the sheets are removed from the furnace, the tubeway system is clean and ready for forming to its final dimensions.

The operation of producing the tubeways is conducted by inflation at very high pressures, the sheet being placed between the flat platens of a hydraulic press during the operation. By this means, tubeways of accurate and uniform height are produced and the walls are work-hardened, thus adding strength and rigidity to the structure. The platens are quite flat and the same platens are used in each instance. Hence, no costly die-sinking operation is necessary.

Provided that a reasonable bend radius is used, the sheets can be bent across the tubeways without flattening the tubes. Simple bending techniques can be employed and recesses are made in the bending tool to clear the tubeways.

An important application of the heat-transfer sheets, of which several thousands a month are already being produced, is in the construction of the domestic refrigerator unit seen in Fig. 3. This photograph is reproduced by the courtesy of the Frigidaire Division of General Motors, Limited. In this instance the ease with which complex tube arrangements can be provided enables designers to grade the "coldness" of the refrigerator shelves and compartments to present the optimum conditions for the storage of various types of food.

The maximum dimensions at present supplied are: length 100 in., width 15 in., and normal thickness 0·06 in. The simplicity of manufacture, coupled with the high heat-transfer efficiency of the sheets and their pleasing appearance suggests that they might be employed in space-heating units, motor-car heaters and radiators, milk coolers and food-processing equipment, and the control surfaces of aircraft.

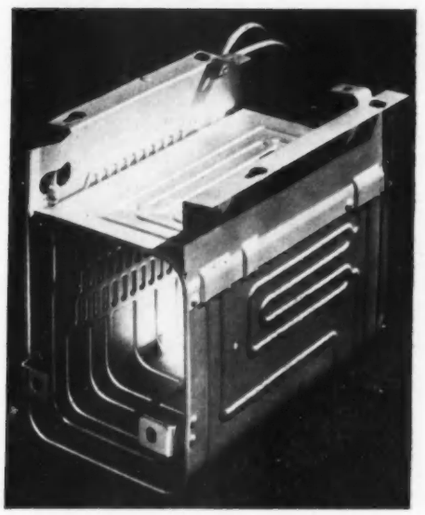


Fig. 3 Refrigerator evaporator unit incorporating the Kynal heat-transfer sheet.

AIR CONDITIONING EQUIPMENT

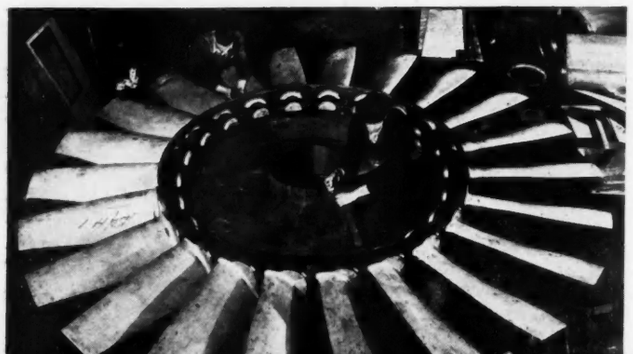
PRODUCTION OF PLANT FOR SHIP AND SHORE

The firm of Thermotank, Limited, Helen-street, Glasgow, S.W.1, was founded in 1901 for the purpose of manufacturing air control and conditioning plant. The business has expanded steadily and now has subsidiaries in Canada, South Africa, United States of America, Australia, Germany and Norway, with associates in some other countries. The majority of the work is probably for ships, except in South Africa, Australia and the United States where 95 per cent. is for offices and factories. Two very large contracts in the United States were for the General Motors Technical Centre and for Fords; including these two, the total work carried out in that country during the last four years has amounted to more than 12 million dols.

Very broadly the units made at Glasgow can be divided into two main types—those which are self-contained and those which draw both hot and cold water from a central supply. The self-contained units are made in three standard sizes having cooling capacities of 12,000, 24,000 and 36,000 B.Th.U. per hour. In the base is the electrically driven refrigeration compressor, above it the air cooling coil, and in the uppermost section the centrifugal fan for circulating the air. The fan is driven independently of the compressor, also by an electric motor. In those units supplied from a central source, circulating chilled (or heated) water replaces the compressor unit and passes through the heat exchanger. Air is again circulated by a fan.

As an alternative to individual units in rooms or cabins, Thermotank also manufacture equipment for circulating hot and cold air, with separate control in each room if desired. Basically, such equipment consists of a central unit in which are two heat exchangers supplied from hot and cold sources, over which a stream of air is blown by a fan. Temperature control is obtained by varying the amounts of air passing over the exchangers (in the single supply system) or by opening louvres in the diffusers in the separate control system.

Apart from direct conditioning units, the firm make circulating fans for mines. An



Air conditioning of mines is essential from the ventilation point of view. The blades of this 160 in. diameter extractor fan can be adjusted for pitch.

example is the 160 in. in diameter fan shown in the illustration. Each blade is a separate sand casting, in aluminium silicon or other corrosion resistant alloy, and is held in the runner by saddle clamps. This method allows the pitch of the blades to be adjusted as required to give the best performance. The particular runner shown is part of a three-stage fan with a capacity of 500,000 cub. ft. of air per minute. Two of these are being supplied to a colliery, and each will be driven by a motor of approximately 1,000 h.p.

MARKING OUT BY PROJECTION

In all air-conditioning plant a great deal of sheet metal work is involved for casings, trunking and the like. To simplify marking out, the developed shapes are drawn to $\frac{1}{5}$ scale on transparent plastics sheets which have been rendered opaque by a colour wash. The plastics sheets are then placed in a projector mounted in the ceiling of a darkened room, and the outlines projected downwards so that they give a full size plan on the sheet of metal to be used. The marker-off scribes along the illuminated lines and the sheet is ready for cutting. It is claimed that an accuracy within $\frac{1}{16}$ in. can be maintained with this system. A magnetic device holds the sheet of metal in place while the lines are being scribed.

After being cut, the sheets are bent to shape and either spot-welded or riveted. Where galvanised sheet is used those parts of the surface damaged by welding or cutting are covered with a zinc-aluminium paint to prevent corrosion—an ever present problem at sea. Similarly, where two metals meet, an insulator is used to prevent electrolytic action. It may be noted here that apprentices do not use the projection system of marking out, but do this by hand. All apprentice work that passes inspection is used which affords a definite incentive.

Several types of louvres and diffusers are made to suit differing requirements. One of the more popular is the ball-and-socket model which is made in several sizes. This is the type that is used to give a mixture of hot and cold air to taste by rotating the socket section to open and close two ports. The ball can also be tilted in the socket to give the required direction of airflow. The unit is made in metal, in which case it is drawn from blanks using rubber dies, or moulded in plastics. In both cases the ball must be a tight but smooth fit in the socket and the port edges sealed so that there is no flow from the hot-air trunking to the cold, or *vice versa*. In the past this has been done by gluing a lining of felt to the interior of the socket, but now an electrostatic method is employed. The half sockets treated with an adhesive, are placed, convex upwards, over a mass of short rayon fibres and given an electrostatic charge. This causes the fibres to be attracted to the socket, but repelled from each other so that all are standing upright. They retain this position long enough for the glue to set and so make a very soft lining, but with sufficient friction to prevent the ball turning by vibration. In view of the large demand for plastics fitments for all types of air conditioning, a separate company has been set up to handle this side of the business.

The heat exchangers used in the various units are of the finned-tube type. They are made by passing tubes through the spaced fins, and then expanding the tubes. To do this, a bullet is fired through the tubes under air pressure, and its diameter is chosen to give the desired expansion and render the tubes a tight fit in the fins. The tube ends are then connected together to form a continuous circulatory system.

In the research section there is a " hot " room where most tropical conditions can be simulated, both for temperature and humidity. As a contrast there is a reproduction of a two-berth cabin fitted with full air conditioning. These two rooms, allow the automatic regulating systems to be demonstrated. Experiments in air flow over ship's superstructure are also carried out in connection with some shipbuilding firms, largely for the purpose of smoke removal.

Obituary

SIR RICHARD FAIREY

With the death of Sir Richard Fairey, founder of the Fairey Aviation Company Limited, which occurred in a London nursing home on September 30, the aircraft industry has lost another of its most notable and active pioneers.

Charles Richard Fairey, born on May 5, 1887, was educated at the Merchant Taylors' School, and at the Finsbury Technical College (City and Guilds). Trained as an electrical engineer, his interest in aviation led him in 1911 to join the Blair Atholl Aeroplane Syndicate at Eastchurch—the centre of aviation activity in those days. In 1913, he became chief engineer to Short Brothers, and two years later he founded his own company at Hayes. Sir Richard's technical contribution include variable-camber gear and one of the first approaches to streamlining.

One of the most advanced aircraft of its day (1924) was the Fairey Fox two-seater day bomber which, owing to its clean design, inspired by Sir Richard, was faster than its contemporary fighter aircraft. The Fairey Swordfish torpedo-bomber-reconnaissance aircraft (1934), was probably the Navy's most successful aircraft in the second World War.

Since the second World War, while continuing their naval association with the second generation of Fireflys (the first Fairey Firefly was of 1930 vintage) and Gannets, Fairey have entered the fields of guided missiles and helicopters, as well as high-speed research aircraft—their FD2 delta-wing aircraft being the current world speed record holder.

Turning from the achievements of Sir Richard's company to his own distinctions:—from 1922 to 1924, he was chairman of the Society of British Aircraft Constructors. He served as a member of the Aeronautical Research Committee from 1923 to 1926, and was President of the Royal Aeronautical Society during the years 1930–31 and 1932–33, and was awarded the Wakefield Gold Medal of the Society for the invention and development of the wing flap.

NOTICES OF MEETINGS

Association of Supervising Electrical Engineers

LONDON
" Relays and Automatic Control in Industry," by Dr. W. L. Stern. Central London Branch. White Hall Hotel, Bloomsbury-square, W.C.1. Mon., Oct. 8, 7.30 p.m.
" Electrical Branch of the Royal Navy," by Commander P. A. Watson. South West London Branch. Prince of Wales Hotel, S.W.19. Thurs., Oct. 11, 7.30 p.m.
BIRMINGHAM
" Valves for Industry," by R. G. Roach. Birmingham Branch. Birmingham Exchange and Engineering Centre, Stephenson-place, Birmingham, 2. Wed., Oct. 10, 7.30 p.m.
SOUTHSEA
" Motor Control Gear," by R. F. Mathieson. Portsmouth Branch. Royal Beach Hotel, Southsea. Thurs., Oct. 11, 8 p.m.

British Institute of Management

GLASGOW
" The Sales Manager and Production Management," by Peter Randolph. St. Enoch Hotel, Glasgow. Mon., Oct. 15, 7.15 p.m.

British Institution of Radio Engineers

GLASGOW
" The Digital Computer and Its Applications," by Dr. A. Barnett. Scottish Section. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Thurs., Oct. 11, 7 p.m.
WOLVERHAMPTON
Discussion on " Television." West Midlands Section. Wolverhampton and Staffordshire Technical College, Wulfruna-street, Wolverhampton. Wed., Oct. 10, 7.15 p.m.

Building Centre

LONDON
Films on " Joints in Civil Engineering and Building " and " Joints that Move." Wed., Oct. 10, 12.45 p.m.

Chemical Engineering Group

LONDON
Film Evening. 14 Belgrave-square, S.W.1. Tues., Oct. 9, 5.30 p.m.

Chemical Society

BELFAST
" Chemistry and the Causeway," by E. M. Patterson. Northern Ireland Branch. Queen's University, Belfast. Tues., Oct. 9, 7.15 p.m.
BIRMINGHAM
"Acetylene-Allene Chemistry," by Professor E. R. H. Jones. Birmingham Branch. Chemistry Department, The University, Birmingham. Fri., Oct. 12, 4.30 p.m.

Illuminating Engineering Society

LONDON
Presidential Address on " Lighting and Social History," by W. E. Harper. Royal Institution, 21 Albemarle-street, W.1. Tues., Oct. 9, 6 p.m.
LIVERPOOL
Chairman's Address by F. J. Burns. Liverpool Centre. Liverpool Engineering Society, 9 The Temple, 24 Dale-street, Liverpool. Tues., Oct. 9, 6 p.m.
SHEFFIELD
Chairman's Address by F. A. Benson. Sheffield Centre. Medical Library, The University, Western Bank, Sheffield, 10. Mon., Oct. 8, 6.30 p.m.

Incorporated Plant Engineers

DUNDEE
Discussion, with film, on " Silicones." Dundee Branch. Mathers Hotel, Dundee. Mon., Oct. 8, 7.30 p.m.
GLASGOW
" Industrial Psychology," by C. A. Oakley. Glasgow Branch. Scottish Building Centre, 425-427 Sauchiehall-street, Glasgow, C.2. Thurs., Oct. 11, 7.15 p.m.
MANCHESTER
" Industrial Drying," by R. R. Clegg. Manchester Branch. Engineers' Club, Albert-square, Manchester. Tues., Oct. 9, 7.15 p.m.
NEWCASTLE-UPON-TYNE
" Stokers and Boilers," by K. Holdsworth. North East Branch. Roadway House, Oxford-street, Newcastle-upon-Tyne. Thurs., Oct. 11, 7 p.m.
NOTTINGHAM
" Germany and the Fuel Problem," by E. G. Phillips. East Midlands Branch. County Hotel, Theatre-square, Nottingham. Wed., Oct. 10, 7 p.m.

Institute of British Foundrymen

BEDFORD
Presidential Address by A. F. Hammond; and Film Display. Bedfordshire and Hertfordshire Section. At works of W. H. Allen, Sons & Co. Ltd., Bedford. Thurs., Oct. 11, 7.30 p.m.
SLOUGH
" Continuous Casting of Bronze," by Dr. E. C. Ellwood. Slough Section. Lecture Theatre, High Duty Alloys Ltd., Slough. Tues., Oct. 9, 7.30 p.m.
THORNABY-ON-TEES
" Foremanship," by F. Shepherd. Tees-side Branch. At Teesdale Hall of Head, Wrightson & Co. Ltd., Thornaby-on-Tees. Fri., Oct. 12, 7 p.m.

Institute of Marine Engineers

LONDON
Presidential Address on " Marine Engineering as a Part of the Shipping Industry," by Sir Donald F. Anderson. Tues., Oct. 9, 5.30 p.m.*
BIRMINGHAM
" Oil Firing for Boilers," by L. Baker. West Midlands

Section. Birmingham Exchange and Engineering Centre, Stephenson-place, Birmingham, 2. Thurs., Oct. 11, 7 p.m.

GLASGOW
"General Observations on Marine Machinery," by Captain N. J. H. D'Arcy. Scottish Section. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Wed., Oct. 10, 7.30 p.m.

LIVERPOOL
"Fire in Cargo Ships," by A. M. Bennett. Merseyside and North Western Section. Central Public Libraries, William Brown-street, Liverpool. Wed., Oct. 10, 6.30 p.m.

NEWCASTLE-UPON-TYNE
"Some Cases of Marine Insurance and Salvage," by Gavin Black. North East Coast Section. Stephenson Building, King's College, Claremont-road, Newcastle-upon-Tyne. Thurs., Oct. 11, 6.15 p.m.

Institute of Road Transport Engineers

BIRMINGHAM
"Current Trends in Fuel-Injection Equipment for Road Transport," by J. Skinner. Midlands Centre. Birmingham Exchange and Engineering Centre, Stephenson-place, Birmingham, 2. Tues., Oct. 9, 7.30 p.m.

BRISTOL
"Design and Construction of a Modern Goods-Carrying Vehicle," by A. S. C. Marks. Western Centre. Royal Hotel, Bristol. Tues., Oct. 9, 7.30 p.m.

LIVERPOOL
"Use of Glass Fibres with Polyenether Resin in Vehicle Bodies," by A. R. Henning. West Regional Centre. Adelphi Hotel, Lime-street, Liverpool. Thurs., Oct. 11, 7.30 p.m.

MANCHESTER
"Two-Way Radio as an Aid to the Control of Goods and Passenger Vehicles," by E. N. Farrer. East Regional Centre. Houldsworth Hall, 90 Deansgate, Manchester. Mon., Oct. 8, 7.30 p.m.

Institution of Civil Engineers

LONDON
"Factors Influencing the Choice of the Right Dredger," by Dr. J. A. Ringers. Maritime and Waterways Division. Tues., Oct. 9, 5.30 p.m.*

EDINBURGH
Chairman's Inaugural Address by S. A. Findlay. Edinburgh and East of Scotland Association. North British Hotel, Edinburgh. Wed., Oct. 10, 6 p.m.

HULL
Chairman's Address by W. Morris. Yorkshire Association. Offices of the Yorkshire Electricity Board, Ferensway, Hull. Wed., Oct. 10, 6.15 p.m.*

Institution of Electrical Engineers

LONDON
Chairman's Address on "The Measurement of Radioactivity," by Dr. Denis Taylor. Measurement and Control Section. Tues., Oct. 9, 5.30 p.m.*
Chairman's Address on "Balanced Development and Diversity of Applications," by H. J. Gibson. Utilization Section. Thurs., Oct. 11, 5.30 p.m.*

BELFAST
Chairman's Address on "A Few Remarks About Switchgear," by Douglas Parry. Northern Ireland Centre. Engineering Department, Queen's University, Belfast. Tues., Oct. 9 6.30 p.m.

BRISTOL
Chairman's Address by Dr. G. H. Rawcliffe. Western Centre Engineering Laboratories, University Walk, Bristol. Mon., Oct. 8, 6 p.m.

FARNBOROUGH
"An On-Off Servomechanism with Predicted Change-over," by J. F. Coales and A. R. M. Norton. Southern Centre. Royal Aircraft Establishment Technical College, Farnborough. Wed., Oct. 10, 7.30 p.m.

HULL
"Protection of Electrical Supply Networks," by E. G. Hopper. North Midland Centre. Offices of the Yorkshire Electricity Board, Ferensway, Hull. Thurs., Oct. 11, 7.15 p.m.

LOUGHBOROUGH
Annual General Meeting. Chairman's Address by Dr. H. L. Haslegrave. East Midland Centre. Loughborough College, Loughborough. Tues., Oct. 9, 7 p.m.

Institution of Engineering Designers

LONDON
"Design in Reinforced Plastics," by S. F. Page. Thurs., Oct. 11, 6.45 p.m.

NEWCASTLE-UPON-TYNE
"Oil Seals and Packings from the Designer's Point of View," by Dr. E. T. Jagger. North East Branch. Northern Architectural Association, 6 Higham-place, Newcastle-upon-Tyne. Mon., Oct. 8, 7.15 p.m.

Institution of Heating and Ventilating Engineers

LONDON
"Mechanical Services for Large Office Buildings," by L. C. A. Walford. Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, S.W.1. Wed., Oct. 10, 6 p.m.*

BIRMINGHAM
"Dust Control in Foundries," by D. Bamford. Birmingham Branch. Birmingham Exchange and Engineering Centre, Stephenson-place, Birmingham, 2. Tues., Oct. 9, 6.30 p.m.

BRISTOL
"Some Aspects of Intermittent Heating," by E. Harrison. South Western Branch. R.W.A. School of Architecture Library, Bristol. Tues., Oct. 9, 6.30 p.m.

Institution of Mechanical Engineers

LONDON
Address by the chairman of the Automobile Division. Tues., Oct. 9, 6 p.m.*
Open Meeting. London Graduates' Section. Thurs., Oct. 11, 6.30 p.m.*

COLCHESTER
"United Kingdom Petroleum Industry: Some Aspects of Its Development," by J. W. Eyre. Eastern Branch. Red Lion Hotel, Colchester. Thurs., Oct. 11, 7.30 p.m.

LEEDS
"The Free-Piston Gas Generator and Its Applications," by P. Watson. Yorkshire Branch. Chemistry Lecture Theatre, The University, Leeds. Thurs., Oct. 11, 6.30 p.m.

NEWCASTLE-UPON-TYNE
Discussion on "The Testing of Boilers and Turbo-Alternators in Power Stations of the Central Electricity Authority," opened by H. S. Horsman. North Eastern Branch. Stephenson Building, King's College, Claremont-road, Newcastle-upon-Tyne. Thurs., Oct. 11, 6.15 p.m.

Institution of Naval Architects

LONDON
"Yacht Testing," by Dr. J. F. Allan, D. J. Doust and B. E. Ware. Thurs., Oct. 11, 4.45 p.m.*

Institution of Production Engineers

DONCASTER
"The Production Engineer and Work Study," by Dr. J. E. Faraday and G. H. Case. East and West Ridings Region. Danum Hotel, Doncaster. Tues., Oct. 9, 7 p.m.

DUNDEE
"Machine Tools from Wilkinson to Automation," by R. Gabriel. Dundee Section. New Imperial Hotel, 15 Tally-street, Dundee. Wed., Oct. 10, 7.30 p.m.

EDINBURGH
"Welding and Marine Engineering," by J. A. Dorrett. Edinburgh Section. North British Hotel, Princes-street, Edinburgh. Wed., Oct. 10, 7.30 p.m.

LEICESTER
"Ultrasonic Machining of Hard Materials," by C. F. Broklesbury. Leicester Section. Bell Hotel, Leicester. Thurs. Oct. 11, 7 p.m.

Institution of Works Managers

BIRMINGHAM
"A National Wages Policy Now!" by N. Campbell Balfour. Birmingham Branch. Midland Institute, Paradise-street, Birmingham. Tues., Oct. 9, 7 p.m.

Junior Institution of Engineers

LONDON
"Problem of Organisation and Methods Study," by W. J. Kease. Fri., Oct. 12, 7 p.m.*

MANCHESTER
Annual General Meeting. Presidential Address by T. S. Dickinson. North Western Section. Engineers' Club, Albert-square, Manchester. Mon., Oct. 8, 7.30 p.m.

SHEFFIELD
Annual General Meeting. Chairman's Address on "Developments in the Motor Industry (Service Side)," by H. C. Bentley. Sheffield Section. 44 Union-street, Sheffield, 1. Mon., Oct. 8, 7.30 p.m.

Liverpool Metallurgical Society

LIVERPOOL
Presidential Address by W. Rose. Liverpool Engineering Society, 9 The Temple, 24 Dale-street, Liverpool. Thurs., Oct. 11, 7 p.m.

Newcomen Society

LONDON
"Origin of the Differential Gear and Its Connection with Equation Clocks," by Dr. Ing. H. von Bertele. Wed., Oct. 10, 5.45 p.m.*

North East Coast Institution of Engineers and Shipbuilders

NEWCASTLE-UPON-TYNE
Presidential Address by R. C. Thompson. Mining Institute, Newcastle-upon-Tyne. Fri., Oct. 12, 6.15 p.m.

Royal Aeronautical Society

LONDON
"The Pressure Jet Helicopter," by Dipl.-Ing. A. Stepan. Section Lecture. Tues., Oct. 9, 7 p.m.

HENLOW
"Rocket Motors," by S. Allen. Henlow Branch. Building 62, R.A.F. Technical College, Henlow. Thurs., Oct. 11, 8 p.m.

Royal Statistical Society

LONDON
"The New Retail Price Index," by Professor R. G. D. Allen. Lighting Service Bureau, 2 Savoy-hill, W.C.2. Wed., Oct. 10, 6.15 p.m.

Sheffield Metallurgical Association

SHEFFIELD
Film Evening. B.I.S.R.A. Laboratories, Hoyle-street, Sheffield, 3. Tues., Oct 9, 7 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

* An asterisk is placed where it is understood that tea is available prior to the time stated.

Association of Supervising Electrical Engineers, 23 Bloomsbury-square, London, W.C.1. (LANgham 5927.)
British Institute of Management, Management House, 8 Hill-street, London, W.1. (GROsvenor 6000.)
British Institution of Radio Engineers, 9 Bedford-square, London, W.C.1. (MUSeum 1901.)
Building Centre, 26 Store-street, London, W.C.1. (MUSeum 5400.)
Chemical Engineering Group, 16 Belgrave-square, London, S.W.1. (BELgravia 3647.)
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Illuminating Engineering Society, 32 Victoria-street, London, S.W.1. (ABBey 5215.)
Incorporated Plant Engineers, 48 Drury-lane, Solihull, Birmingham. (Solihull 3021.)
Institute of British Foundrymen, St. John Street Chambers, Deansgate Manchester 3. (Blackfriars 6178.)
Institute of Marine Engineers, 85 The Minories, London, E.C.3. (ROYal 8493.)
Institute of Road Transport Engineers, 69 Victoria-street, London, S.W.1. (ABBey 6248.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Engineering Designers, 38 Portland-place, London, W.1. (LANgham 8847.)
Institution of Heating and Ventilating Engineers, 49 Cadogan-square, London, S.W.1. (SLOane 3158.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Naval Architects, 10 Upper Belgrave-street, London, S.W.1. (SLOane 4622.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GROsvenor 5254.)
Institution of Works Managers 67-68 Chandos-place, London, W.C.2. (TEMple Bar 8324.)
Junior Institution of Engineers, Pepys House, 14 Rochester-row, London, S.W.1. (VICtoria 0786.)
Liverpool Metallurgical Society, Greenhithe, Grosvenor-road, St. Helens, Lancs. (St. Helens 5879.)
Newcomen Society, Science Museum, Exhibition-road, London, S.W.7. (KENsington 1793.)
North East Coast Institution of Engineers and Shipbuilders, Bolbec Hall, Newcastle-upon-Tyne, 1. (Newcastle 20289.)
Royal Aeronautical Society, 4 Hamilton-place, London, W.1. (GROsvenor 3515.)
Royal Statistical Society, 21 Bentinck-street, London, W.1. (WELbeck 7638.)
Sheffield Metallurgical Association, 66 Ringstead-crescent, Sheffield 10. (Sheffield 62144.)

The new Corrosheath aluminium foil is designed to provide efficient and easily-applied protection for the insulating material enclosing steam and other pipes. The jacketing may be cut with strong scissors and is normally fixed by hand.

ALUMININIUM-FOIL PROTECTION FOR INSULATED PIPES

With the object of providing adequate and hygienic protection for the insulating material enclosing steam, hot-water, chemical and oil pipes, a new form of aluminium covering has been developed by Corrosheath Limited, in conjunction with Venesta Limited, Vintry House, Queen Street Place, London, E.C.4.

The new Corrosheath aluminium jacketing, as it is called, is a great advance over the old "roofing felt and chicken-wire" method in that it protects completely the insulating material, which by nature is fibrous and porous, and is at once efficient and easy to apply. The jacketing is made of 0·006 in. thick aluminium foil and is provided with $\frac{3}{16}$ in. corrugations to give it extra strength. The material used is hard-tempered aluminium, SIC, to B.S. 1470 : 1955.

Generally, the jacketing has a glued on asphaltic moisture barrier consisting of Kraft Union waterproof paper which protects the aluminium from corrosion when the insulating material is alkaline. The jacketing, however, is also supplied plain, without the moisture barrier, for use when the problem of corrosion does not arise. The material is available in rolls 24 in. wide and 100 ft. long and may be cut to size on the site with a pair of strong scissors. As may be seen in the illustration the jacketing is handled and applied by one man who simply cuts the aluminium foil to the required size, wraps it round the insulated pipe and secures it with aluminium straps. In fixing the sheeting, sufficient tension can normally be obtained by hand. The strapping used is supplied in 5 lb. coils and is $\frac{3}{4}$ in. wide and 0·020 in. thick. To provide complete protection, each width of jacketing is made to overlap, and pipe bends are dealt with by the application of 3 in. wide soft-tempered strip aluminium wrapped round the pipe like a bandage. To ensure weather-proofing, a layer of plastic or grease-impregnated tape is usually applied first.

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The Institute of Physics, with the London and Home Counties Regional Advisory Council for Higher Technological Education, are holding a conference "Degree and Diploma Courses in Applied Physics" on November 15 and 16, at the Institution of Electrical Engineers. Details are obtainable from the deputy secretary, Institute of Physics, 47 Belgrave-square, London, S.W.1.

THE HUMAN ELEMENT

Powers of security officers—B.B.C. pay the rate for the job—Engineering workers lead demands for higher wages—South Wales coal miners lead the acceptance of mechanisation—Third Programme and third rate—Shorter working week in the United States ?

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Secret Police

Following the White Paper by the committee of Privy Councillors on security, and more recently the case of Mr. John Lang and I.C.I., a committee has been formed called the " Campaign for the Limitation of Secret Police Powers " to expose abuses in individual cases where security checks are made. The committee is concerned at the powers of security officers to judge from hearsay instead of evidence, and about the damage which may be done to our institutions of individual liberty by such judgment, based as it may be on prejudice and ignorance, at least in part.

The objects and the pre-occupations of the committee are clearly laudable. The price of liberty is eternal vigilance and there is no doubt that the individual is to-day under constant tyrannical pressure from the executive branch of Government. There are even now ways of fighting this type of oppression, however, and it is surprising how few victims (and they tend to be intelligent people) use them. Few seem to write to either M.P's or to the Press. Some hedge under examination.

However, let it be assumed, and it is a very reasonable assumption, that there is need of some organisation to look after these matters. The committee concerned has made two fatal mistakes amounting almost to ingenuousness. In these matters auspices are everything. The sponsoring council is composed to a very large extent of left-wing people, artists (in the broad sense of the word) and a number of liberals. The base is not nearly broad enough for the committee to be considered above reproach and any group contemplating serious and continuous campaigning for civil liberty should have realised it. This sort of thing is just clumsy enough to play into the hands of those who would wish it less than well.

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B.B.C. Pay Rise

Competition on the air has brought a number of problems for the B.B.C.—as it was intended that it should. One of these has been how to keep its staff once direct competition from a similar organisation developed. An outcome has been the decision to give increases in pay to about 15,000 employees back-dated to September 1. The offer embraces all grades of skilled technicians and staff and will cost the Corporation about £750,000 a year. The days when the B.B.C. can offer agreeable employment at knock-down prices are coming to an end.

So far as the staff is concerned, the position has been basically unstable for a long time. The B.B.C. has been a monopoly with all the consequent advantages in the market for certain types of technical and culturally educated labour. In fairness it has also to be said that the terms of that monopoly forced it to sell its services to the public at an absurdly low price. There thus became established a tradition of high quality at a low price which obviously could not stand up in the long run to the conditions of the labour market. The price of well-educated labour has been rising—and not only because of the competition of I.T.A. Time was when well educated young people would take jobs at not very attractive three-figure salaries since many of them enjoyed either a private income or certain amenities. Those days are gone. Most educated people to-day need to take the price of their services as the market values them. The latest pay increase at the B.B.C. is the indication that the market is working.

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Cycle of Wage Claims

Each year the cycle of wage claims gets under way in the autumn. Last year it began with a 14*s.* a week rise for the 53,000 London bus men. This year their claim for £1 a week increase was discussed last week but no decision taken. The talks were adjourned to allow both sides to consider the points raised. A recent claim by the 77,000 municipal bus men has gone to arbitration. Another claim for a similar amount was lodged on behalf of the 100,000 bus workers employed by private companies.

The leaders in wage demands this autumn are the engineering and shipbuilding workers and the railwaymen. The engineering unions' claim has now been formally submitted, and the rejected claim submitted by the Associated Society of Locomotive Engineers and Firemen will be pressed through the Railway Staff National Tribunal. The National Union of Railwaymen and the Transport Salaried Staffs Association are shortly to submit a joint claim. Both the engineering workers and the railwaymen will be resolutely resisted.

The importance of the coming struggle should not be under-estimated. Profit margins are falling, and competition in overseas markets becoming daily more intense. The effect on other industries will be considerable, since what happens in engineering generally sets the pattern for private industry, and what happens on the railways does the same for nationalised industries.

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Coal Workers and Machines

An increase in the machine loading of coal produced in the South Wales coal-field from 9 to 20 per cent. is expected to follow an agreement on piece-work rates concluded last week. Machines which have been idle for six months are expected to start operating very soon. Miners refused to work the machines because there was no agreement on wages. The negotiations between the South Wales area of the National Union of Mineworkers and the South-Western Division of the National Coal Board began early this year. The result is said to be the first piece-work agreement for power loading in British mines.

The men employed on the machines are to be divided into three grades, according to the class of work performed. Top-grade men will get a gross wage of £3 per shift if they clear 80 per cent. of the mutually agreed potential task; if they clear 100 per cent. they will get £3 13*s.* 6*d.* By clearing 80 per cent. throughout the week they will get a weekly wage of £18 7*s.* 6*d.* Second-grade men will get £2 15*s.* 0*d.* per shift and third-grade men £2 10*s.* 0*d.* The executive council of the union recommended acceptance of the agreement and their recommendation was endorsed by a conference of 200 delegates representing 100,000 miners. The recommendation will now go back to pit lodge meetings for final ratification.

The miners have long resisted attempts to mechanise coal mining, even of the most arduous and dirtiest operations. The agreement is a most encouraging development and a lead which is likely to be generally followed.

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Intellectuals in Retreat ?

By a coincidence, the celebration of the tenth anniversary of the Third Programme of the B.B.C. this week has taken place to within a few days of Sir Edwin Herbert's presidential address to the Law Society dealing with the declining prestige of learning. Sir Herbert pointed out that the professions had fallen in public esteem in the last century, and saw in this decline the power in action of the unthinking many over the educated few. To-day's hero was the mechanic who could make things go or the business man who organised it all. The doctor was a mechanic who tinkered with the body, and other professions were in a similar position. Standards were at best those of a craft not those of the professions.

It is very much the difference between the Third Programme and the panel games on television. In the popular esteem, the virtues are a tinselly brightness, a quick and superficial glibness. It's better to be quick than right. By such standards the social crimes are dullness and a failure to entertain or not have ready-made and amusing opinions on a vast variety of subjects. Everything must be reduced to measurable terms. To be better a thing must be bigger, noisier or quicker than the one preceding it.

These are the criteria of an age which has works without faith. The intellectuals (in the best sense of that word) and their numbers in the professions can at least have the consolation that the minority is usually right and that this particular problem will eventually come full circle. After all, no one has greater faith than the man who plays the slot machines.

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Gracious Living for the American Worker

American unions are aiming at a shorter working week as the next major step to improve the working conditions and the standard of living of their members. At a recent national conference in Washington sponsored by the Department of Research of the newly amalgamated American Federation of Labour and Congress of Industrial Organisations, the president of A.F.L.-C.I.O., Mr. George Meany, said " the overall problem of shorter hours lies at the very heart of our economy, and is concerned with the rate of production and the ability to consume what we produce to keep the economy healthy." Mr. Meany told the conference that the displacement of labour by automatic machines must result in shorter hours to maintain full employment and workers' incomes: " we can't produce consumers by push buttons."

This is now a familiar line of argument among organised labour in the U.S., and one to which a great many employers already subscribe. There is a growing feeling that the nation needs more leisure rather than an increased real income per head. One of the papers, read by the assistant director of research, discussed the problem in detail and reviewed likely future developments, such as a four-day week; an occasional 3-day week-end; longer holidays taken in two periods, one in the summer, one in the winter; and a year's leave of absence at 50 or 55 for workers with long seniority. In Detroit, Mr. Walter Reuther, president of the automobile workers, said that his union planned to start seeking a 4-day week in 1958.

These developments, in a country where automation has made greatest progress and is going ahead faster than most people expected, suggest that a social revolution will take place in parallel with the industrial revolution now going on, and that human values will be more to the fore than they have been for half a century. The " Gracious Living " of American advertisements has arrived.

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In quoting figures for productivity at the Volkswagen Works (Human Element, September 7) we deduced that the annual increase in productivity from 1952 to 1955 was 27½ per cent. A correspondent has pointed out that this figure is, in fact, the annual increase in exports per worker. The increase in productivity was 7½ per cent.

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